



Airspace Technology Demonstration 2 (ATD-2)

Surface Metering Briefing – Initial Analysis, Impact, and Evolution
March 21, 2018

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- Keep broad group of ATD-2 stakeholders informed of progress in an inexpensive and unobtrusive manner
- Demonstrate actual system capability and lessons learned (as opposed to documents/plans)
- Take input from stakeholders that can be used to improve the ATD-2 system, processes and/or outreach
- Identify areas where more detailed discussion is desired/warranted

Go to https://www.aviationsystemsdivision.arc.nasa.gov/research/tactical/atd2_remote_demos.shtml to learn about upcoming ATD-2 remote demos!

ATD-2 Remote Demos

To Join...

1. Go to: <https://ac.arc.nasa.gov/atd2/>
Enter as a guest and type your name. NASA Employees can log-in with their email and password (NDC Credentials).
2. Dial the Telecon Number: **1-844-467-6272, Passcode: 592382#**

Demo Objectives

- Keep broad group of ATD-2 stakeholders informed of progress in an inexpensive and unobtrusive manner
- Demonstrate actual system capability and lessons learned (as opposed to documents/plans)
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Upcoming Demos

Latest IADS capabilities
Surface Metering - Initial Analysis, Impact, and Evolution

Mar. 14, 8:00-9:30 PT
Mar. 21, 8:00-9:30 PT

- The audio and video from this demo are being recorded

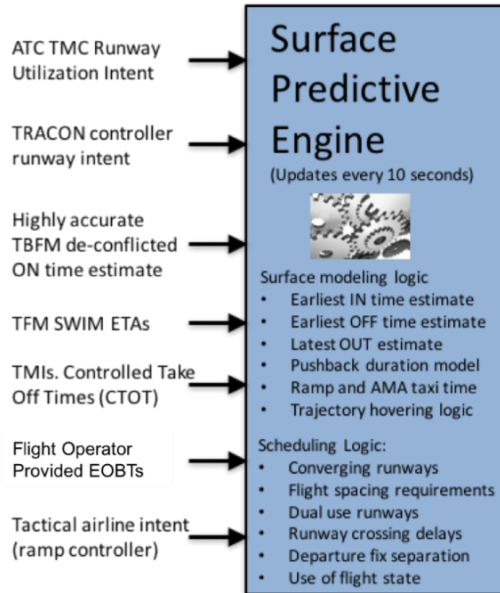


**RECORDING
IN PROGRESS**

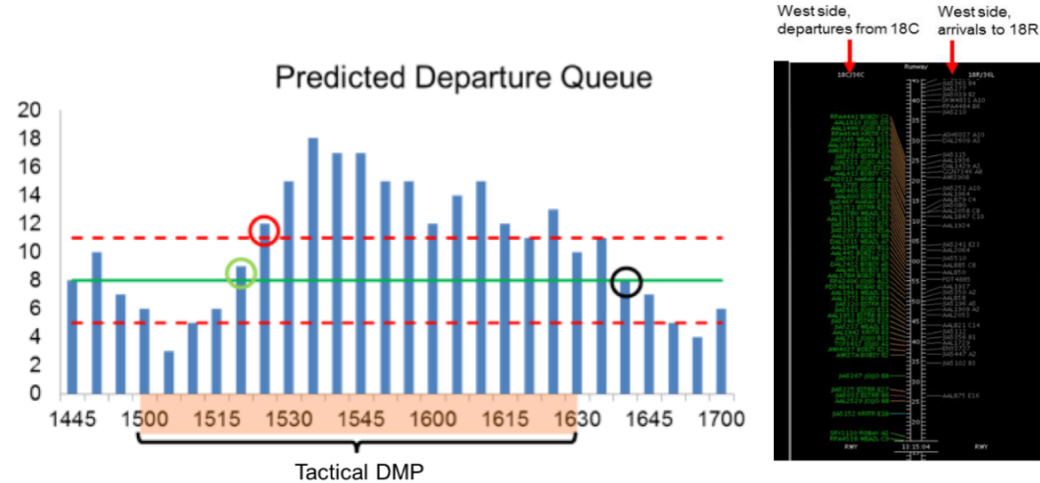
- Background
- Evolution in Tactical Scheduler and Transition to Strategic Planning
- Initial Surface Metering Analysis Results
- Lessons Learned
- Next steps
- User Feedback / Q&A

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1 Generate Demand and Capacity Predictions



2 Monitor Surface Demand Capacity Imbalances



"What If" available. If Surface Metering, Go to Step 3

3 Enable Metering. Set Hold Level

Surface Metering Display

Configuration: North Scenario: N 8U/AT-36C Time: 2018-03-09 15:07:37 Excess Queue Time Feedback

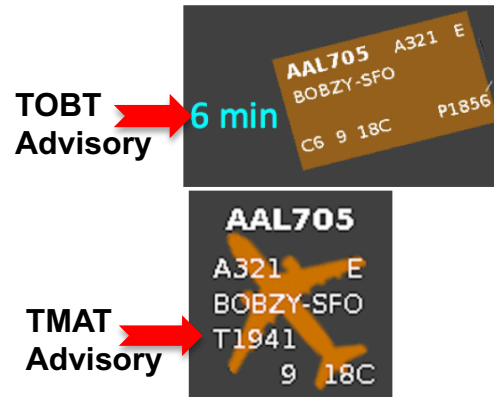
36C

Parameter	Current Value	New Value
Enable Metering	TIME BASED METERING	Disabled
Upper Threshold	10 min	
Target Excess Queue Time	8 min	
Lower Threshold	5 min	

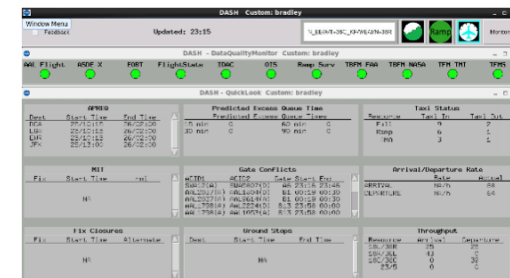
36R

Parameter	Current Value	New Value
Upper Threshold	12 min	
Target Excess Queue Time	10 min	
Lower Threshold	7 min	

4 Honor TOBT and TMAI advisories



5 Evaluate Metering Effectiveness



- Background
- Evolution in Tactical Scheduler and Transition to Strategic Planning
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- Refresher on order of consideration
- Order of Consideration Modifications
- Metering parameter changes
- Metering display triggering on/off

Arrivals	Departures						
TBFM and TFM	APREQ	EDCT	Taxi	Exempt	Ready	Planned	Uncertain

- The order of consideration defines the order from which flights are inserted into the scheduling algorithm.
- The highest precedence is from left to right.
- The ordering with each group is set by FCFS (First Come First Serve) with the exception of the Planned group which is FSFS (First Schedule First Serve)

Arrivals		Departures							
TBFM and TFM		APREQ	EDCT	Taxi	Exempt	Ready	Planned	Uncertain	
TBFM	TFM	AMA Taxi	APREQ	EDCT	Ramp Taxi	Exempt	Ready	Planned	Uncertain

- Arrivals
 - Handling arrivals: TFM flights vs. TBFM flights with STAs
 - Every flight in AMA based on FCFS including TMI flights
- Departures
 - Previous algorithm showed APREQ and EDCT flights scheduled at the release times.
 - The current algorithm distinguished AMA taxi from Ramp taxi flights. This modification shows APREQ and EDCT flights scheduled at the release time until the flight moves into the AMA.
 - This change give controllers insight into when the flight could take off on the timeline.
 - Late and early APREQ flight times can be renegotiated.

- Tower TMC and Ramp Manager collaboratively determine surface metering and decide target excess queue time and upper & lower thresholds
- User interface has been migrated from RMTC to an independent web-based Surface Metering Display (SMD)
- Allow for setting metering parameters per runway

Setting Metering Parameters per Runway

Surface Metering Display
Configuration: North
Scenario: N_BE/A/T=36C
Time: 2018-03-09 15:07:57
Excess Queue Time
Feedback

Airport

Parameter	Current Value	New Value
Enable Metering:	TIME_BASED_METERING	<input type="radio"/> Disabled <input checked="" type="radio"/> Enabled

Set Airport Parameters
Clear Airport Parameters

36C

Parameter	Current Value	New Value
Upper Threshold:	10 min	<input type="text"/> min
Target Excess Queue Time:	8 min	<input type="text"/> min
Lower Threshold:	5 min	<input type="text"/> min

Set Rwy 36C Parameters
Clear Rwy 36C Parameters

36R

Parameter	Current Value	New Value
Upper Threshold:	12 min	<input type="text"/> min
Target Excess Queue Time:	10 min	<input type="text"/> min
Lower Threshold:	7 min	<input type="text"/> min

Set Rwy 36R Parameters
Clear Rwy 36R Parameters

- Metering display algorithm modified to take into account the runway queue as well as the scheduled excess queue time for flight at the gate
 - For entering metering, the target queue value must be met for a taxi departure and the upper threshold must be met for a gate departure
 - For exiting metering, the excess queue times for all taxi flights and gate departures within the time horizon must be less than the lower threshold
- These changes help to:
 - Front load the bank prior to metering
 - Prevent fluttering in metering triggering on/off
 - Prevent false positive results

Note: Latest update to the software for this change is coming soon in the next patch release.

Transition to Strategic Planning

- Goals
 - Incorporate lessons learned from tactical scheduler during Phase 1
 - Incorporate additional concepts from Surface CDM for strategic timeframe and provide tech transfer benefits to TFDM
 - Provide planning tools on the strategic timeframe
 - Provide predictions at longer look-ahead times
 - Provide advanced notice of metering
 - Provide TOBTs and TMA Ts with more lead time
 - Continue to make use of tactical data, such as readiness information
- Strategic planning tools will be added on top of the existing tactical scheduler
 - Departure Metering Procedures (DMPs) will be added from the Surface CDM/TFDM concepts

- Ramp Manager and TMC coordinate on metering parameters
 - Parameters are set per runway
 - The metering mode is set to Time-Based Metering
- At a future point in time, the scheduler tactically triggers metering for each runway based on the runway's parameters
 - Gate holds are displayed on RTC for flights
 - No advanced warning that metering will turn on or off
 - Limited information about the expected size of gate holds

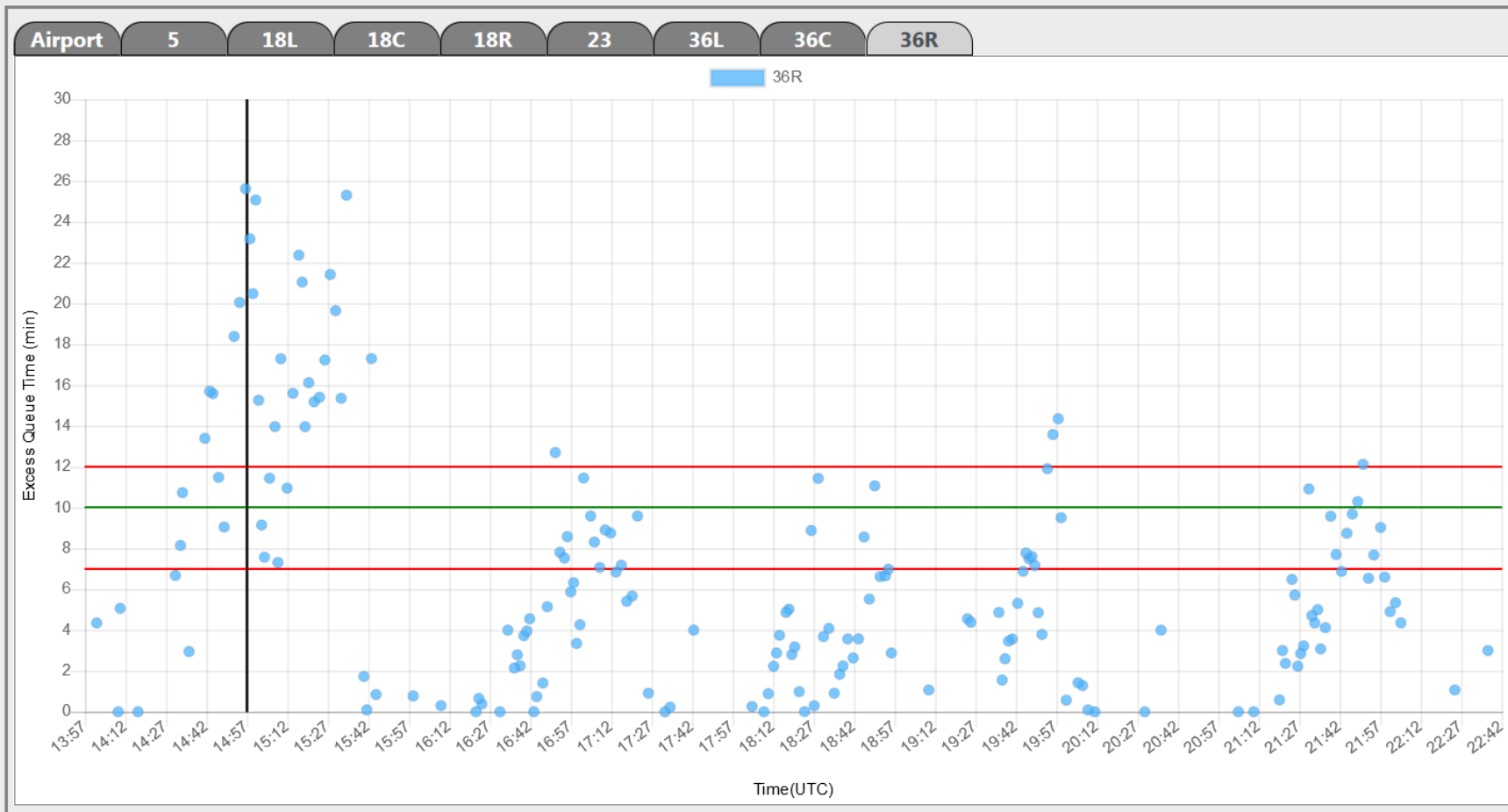
Surface Metering Display

Configuration: North

Scenario: N_BE/A/T=36C

Time: 2018-03-09 14:57:37

Metering Params Feedback



Operational STBO Toolbar

[TM Actions](#)
[Create](#)
[Show Window](#)
[Settings](#)
[Delays](#)
[Search](#)

[Clear](#)

NEW 39
APREQ to DCA 1130-0200
N_BE/A/T=36C

Metering indications per runway



Surface Metering Display Configuration: North Scenario: N_BE/A/T=36C Time: 2018-03-09 15:07:57 Excess Queue Time Feedback

Airport

Parameter	Current Value	New Value
Enable Metering:	TIME_BASED_METERING	<input type="radio"/> Disabled <input checked="" type="radio"/> Enabled

[Set Airport Parameters](#)
[Clear Airport Parameters](#)

36C

Parameter	Current Value	New Value
Upper Threshold:	10 min	<input type="text"/> min
Target Excess Queue Time:	8 min	<input type="text"/> min
Lower Threshold:	5 min	<input type="text"/> min

[Set Rwy 36C Parameters](#)
[Clear Rwy 36C Parameters](#)

36R

Parameter	Current Value	New Value
Upper Threshold:	12 min	<input type="text"/> min
Target Excess Queue Time:	10 min	<input type="text"/> min
Lower Threshold:	7 min	<input type="text"/> min

[Set Rwy 36R Parameters](#)
[Clear Rwy 36R Parameters](#)

Metering parameters per runway



- DMPs provide advanced notice of metering
 - Predicted start and stop times of metering
 - Statistics on gate holds for all flights in a DMP
- ATD-2 will propose a DMP and metering will only happen if a user affirms the need for the DMP
- No changes to ramp controller procedures
 - Gate holds are shown on RTC in the same way they are today
- Changes are only to the planning tools for ramp managers and TMCs

Upcoming Surface Metering Display Changes



Surface Metering Display

Configuration: North

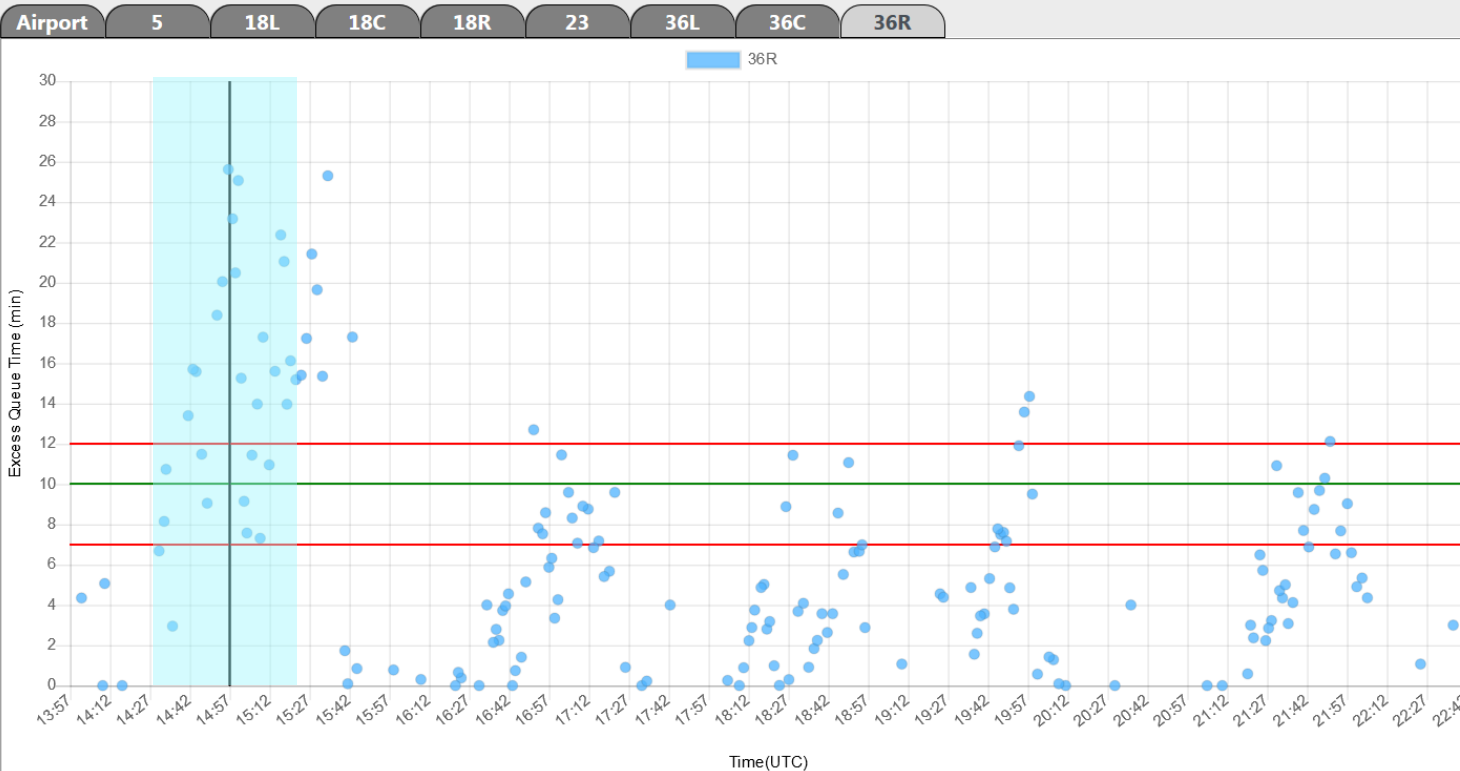
Scenario: N_BE/A/T=36C

Time: 2018-03-09 14:57:37

Metering Params Feedback

Departure Metering Procedures

Status ▼	Rwy ▼	Start ▼	End ▼	Flight Count ▼	Avg Gate Hold ▼	Max Gate Hold ▼
Affirmed	36C	09 1505	09 1610	10	5 min	12 min
Active	36R	09 1430	09 1525	15	6 min	15 min



- Background
- Evolution in Tactical Scheduler and Transition to Strategic Planning
- **Initial Surface Metering Analysis Results**
- Lessons Learned
- Next steps
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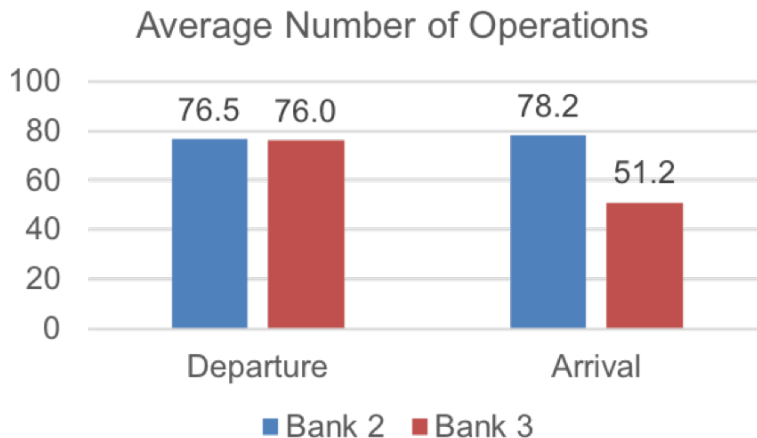
- Surface Metering Usage
 - Number of days of surface metering
 - Avg. number of metered flights vs. flights actually held at gate
- Assessment of surface metering effectiveness
 - Total and excess taxi out/in time
 - Count of aircraft with large excess queue time
 - Gate conflicts
 - TOBT compliance*
 - Figures of merit*
- Post-ops benefit metrics
 - Avg. gate hold time
 - Avg. taxi out/in time in AMA and Ramp
 - Fuel/emissions savings
 - On-time performance

* work in progress

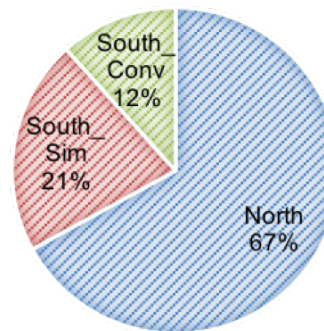
Surface Metering Usage (As of March 11)



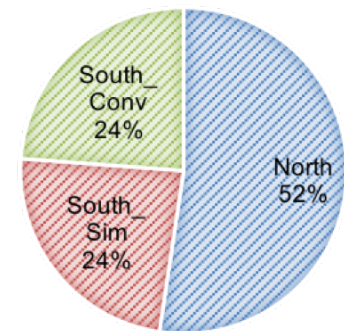
- Surface metering started in late Nov 2017 (Phase 1C)
 - for 90 of 103 days since Nov 29, 2017 for Bank 2
 - for 16 of 21 days since Feb 19, 2018 for Bank 3
 - Weather and deicing operations were main factors that prevented surface metering from being used in this time period
- Surface metering has occurred across numerous runway configurations and meteorological conditions
 - Given the variance in day to day operations in terms of runway utilization, number of controlled flights, density of the bank, changes in overlap in departures and arrivals, the data is being carefully analyzed.



BANK 2:
11/29/17~3/11/18

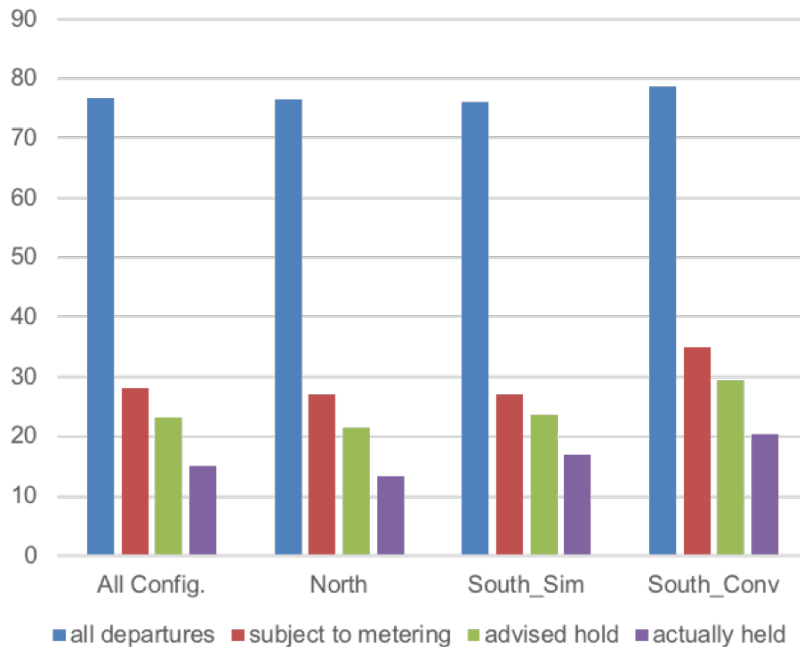


BANK 3:
2/19/18~3/11/18

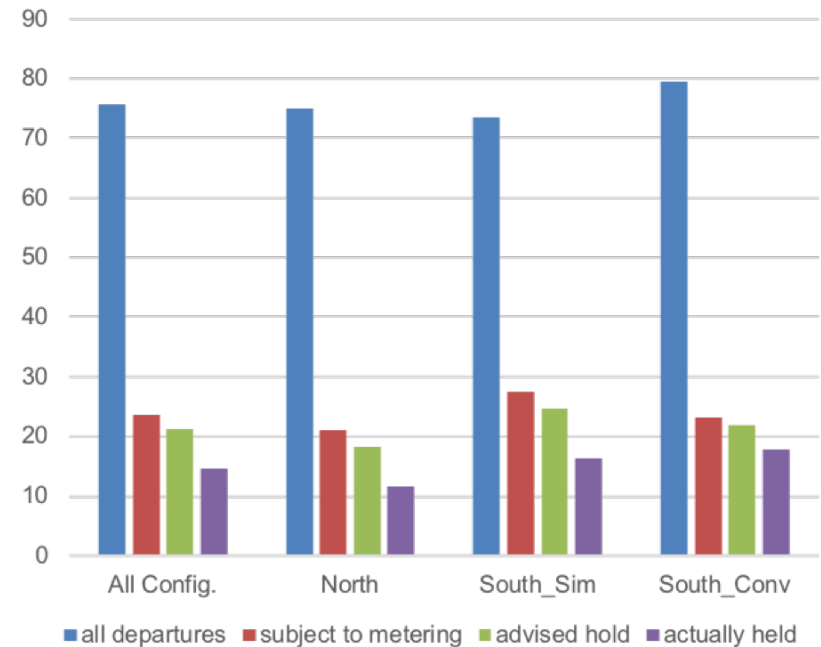


- Among all the departures in Bank 2 or 3
 - About 31~37% of departures were subject to surface metering
 - About 28~30% of departures were advised “Hold”
 - The number of departures actually held at gate are even fewer

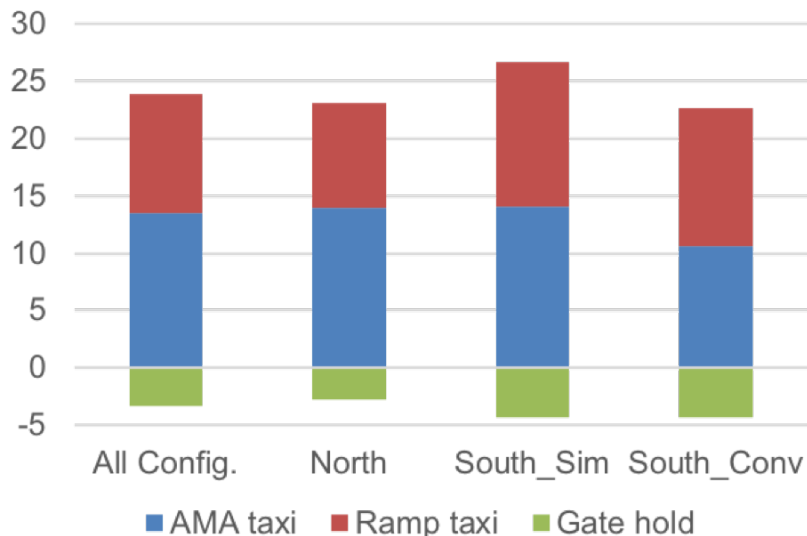
Bank 2: 11/29/17~3/11/18



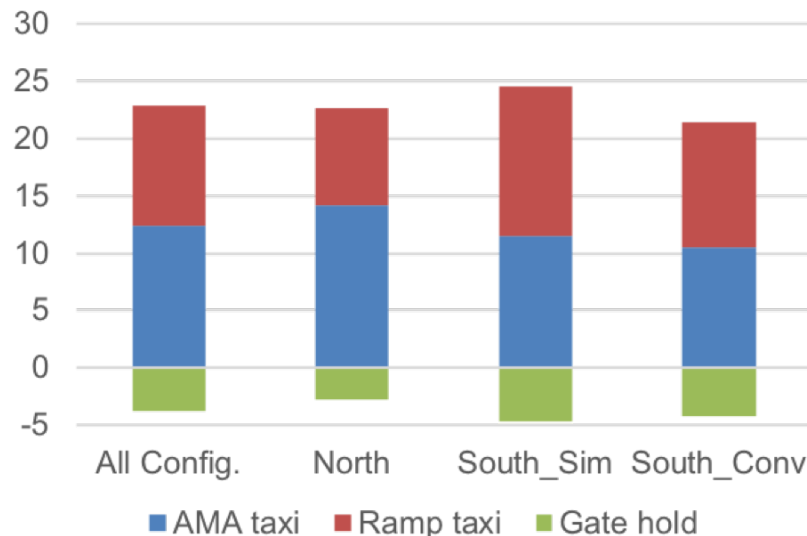
Bank 3: 2/19/18~3/11/18



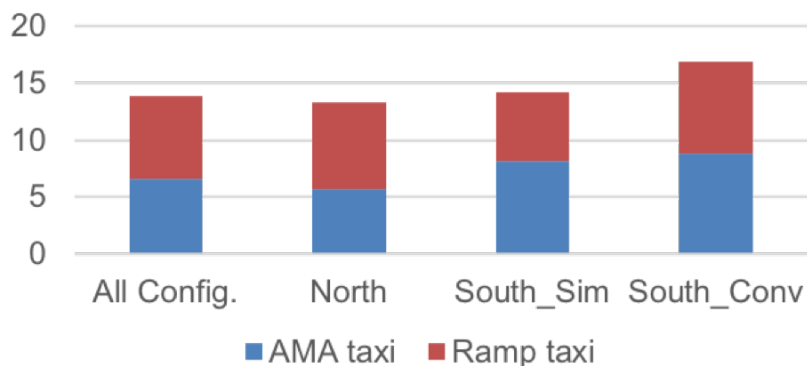
Avg. Taxi-out Time and Gate Hold - Bank 2



Avg. Taxi-out Time and Gate Hold - Bank 3

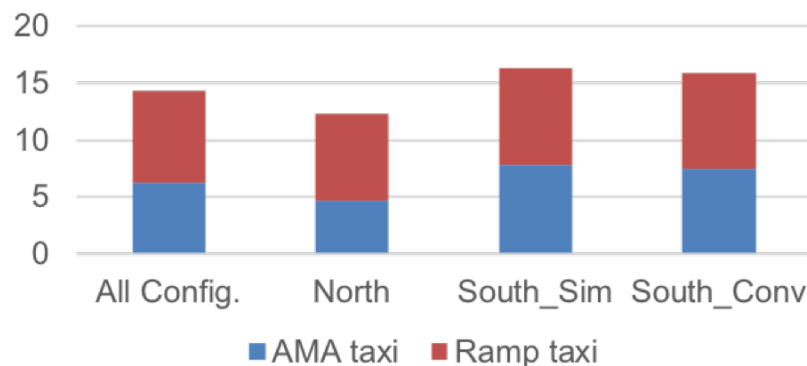


Avg. Taxi-in Time - Bank 2

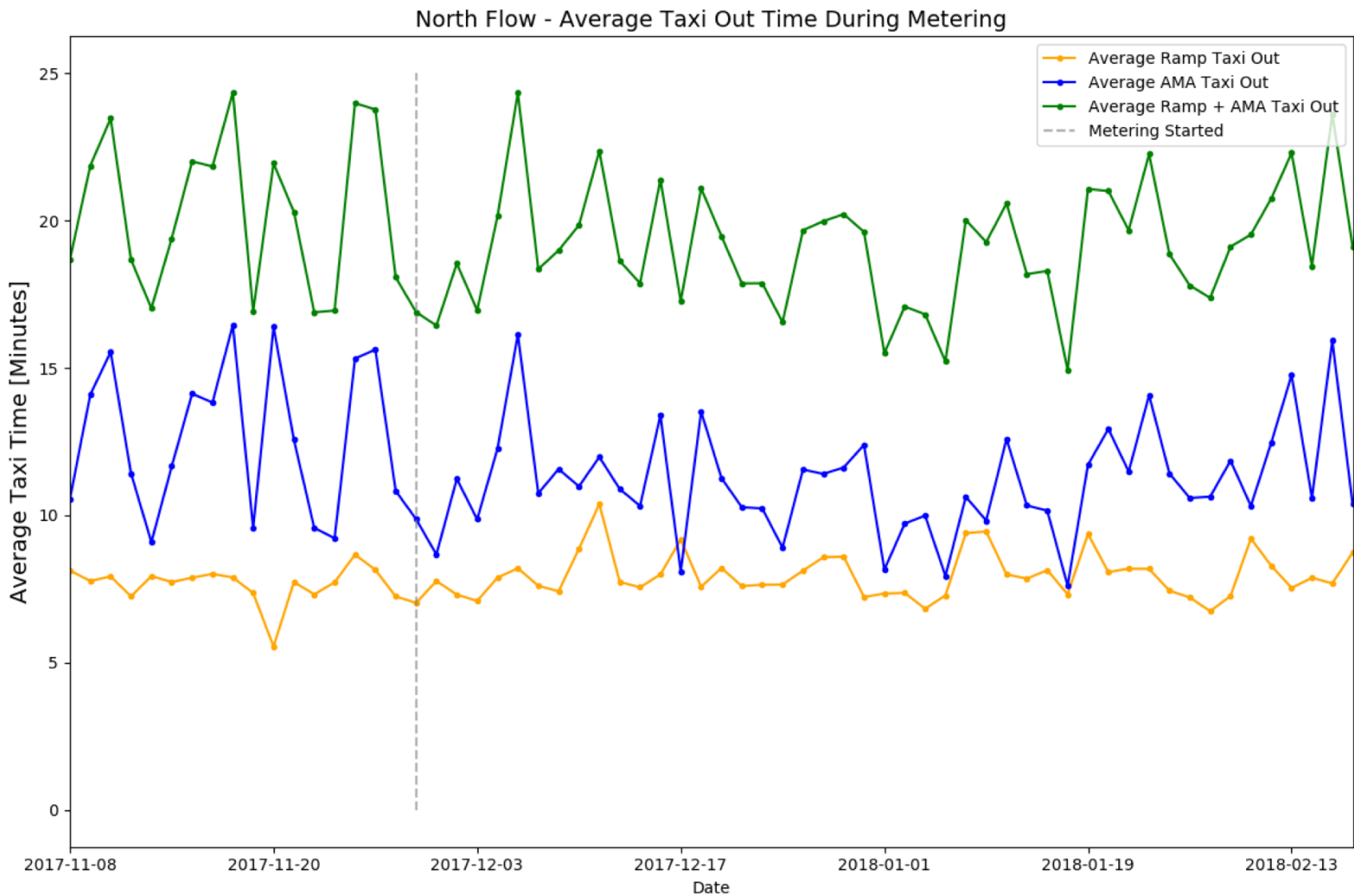


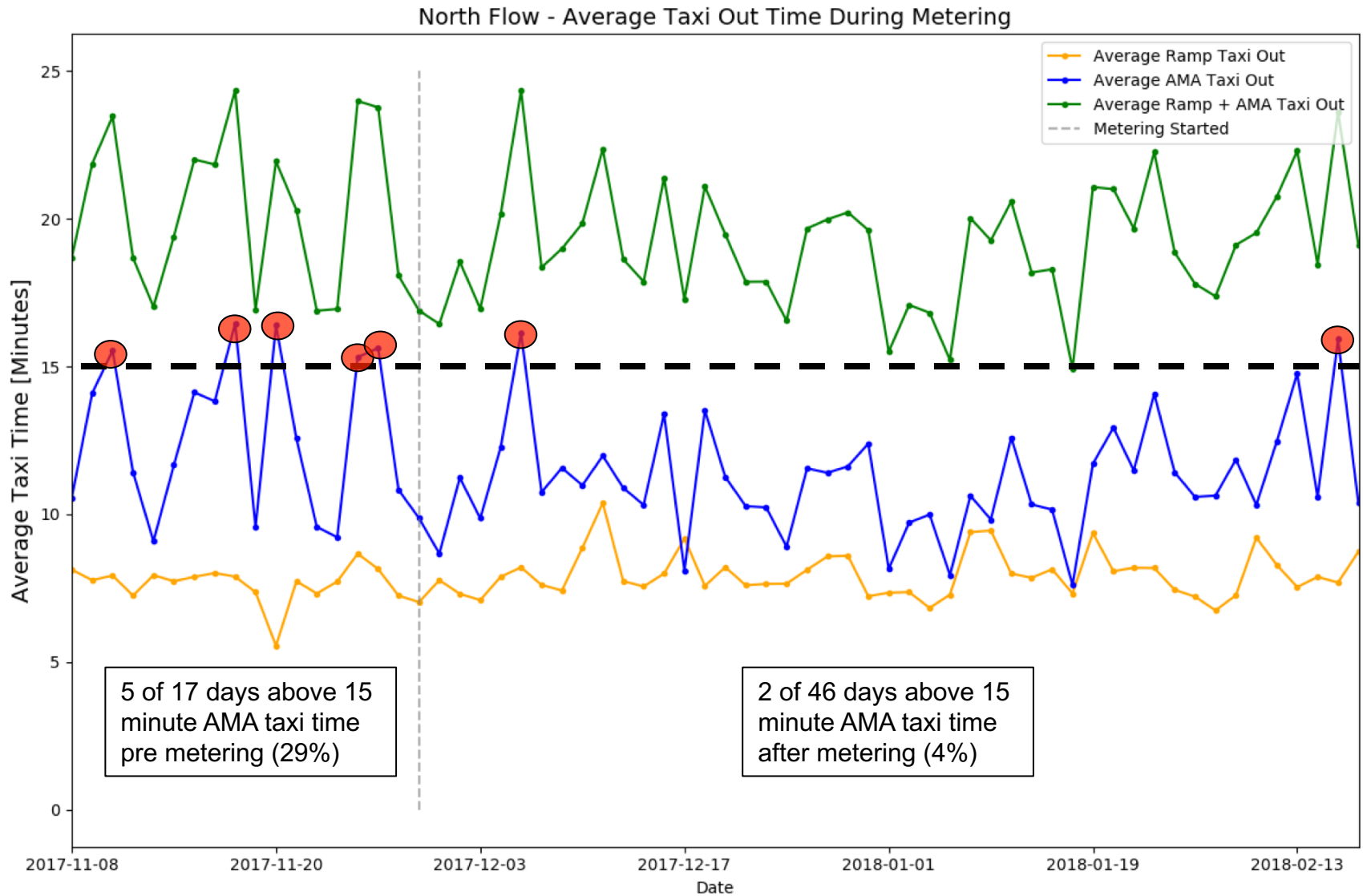
Bank 2: 11/29/17 ~ 3/11/18

Avg. Taxi-in Time - Bank 3



Bank 3: 2/19/18 ~ 3/11/18



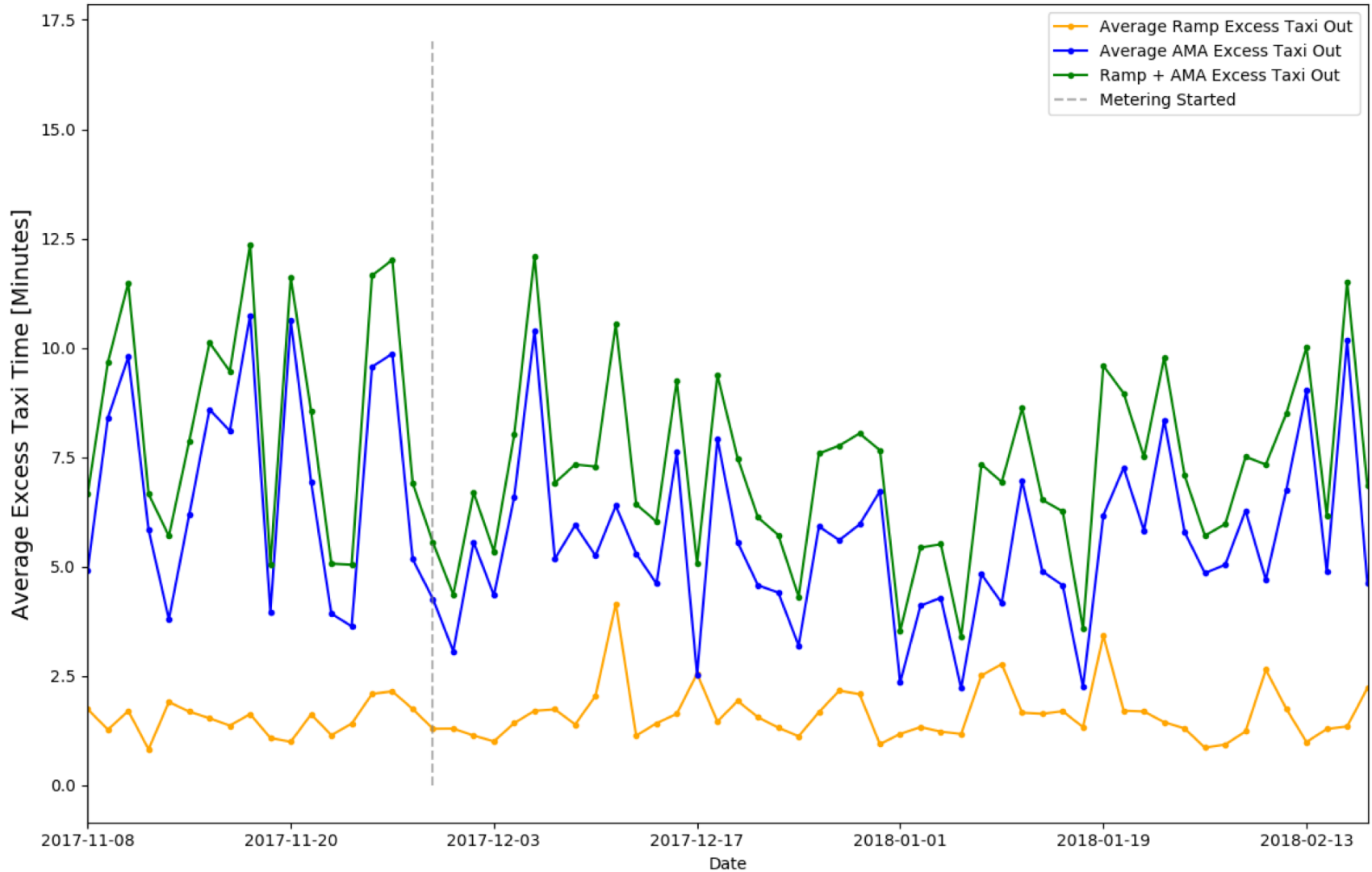


- Due to the geometry of the airport, the gate and runway locations can increase taxi time without increasing delay
- We can analyze the excess taxi time to reduce the impact the geometry of the airport has on the taxi time metrics
- **Excess taxi time** = (Actual taxi time – unimpeded taxi time)
- The unimpeded taxi time comes from the surface model and is calibrated from historical data

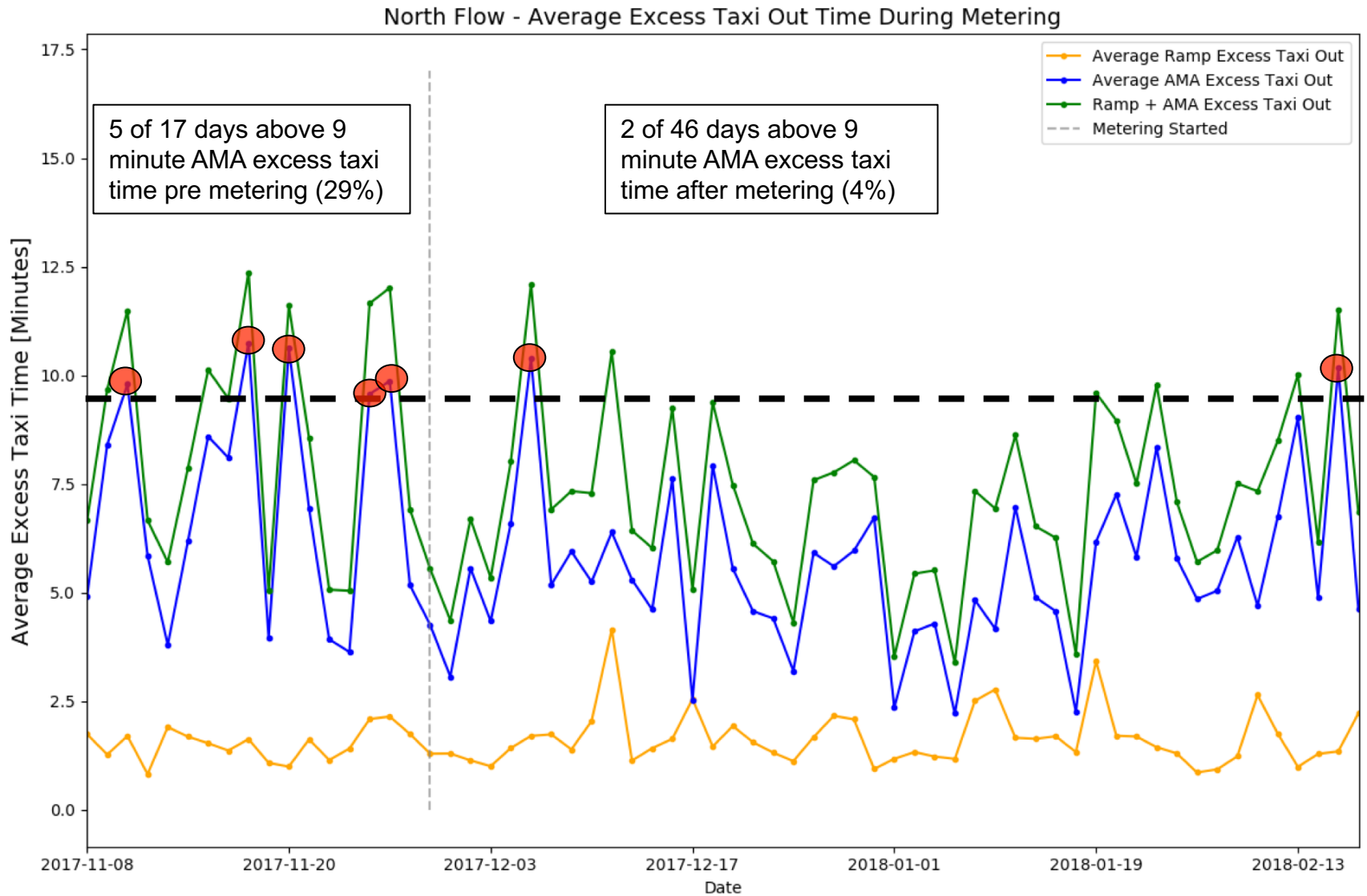
Bank 2 North Flow Average Excess Taxi Out Time

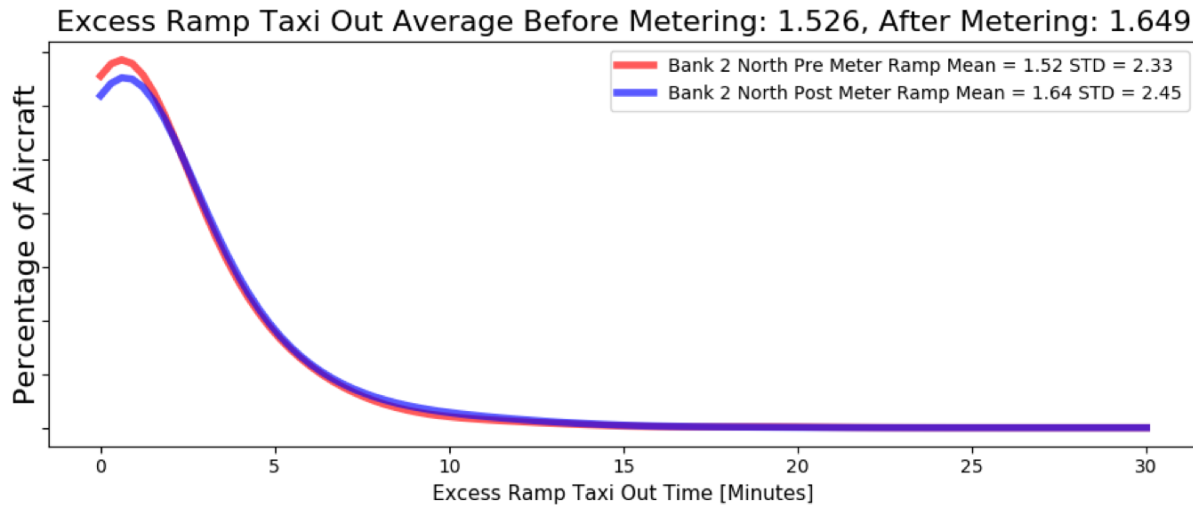
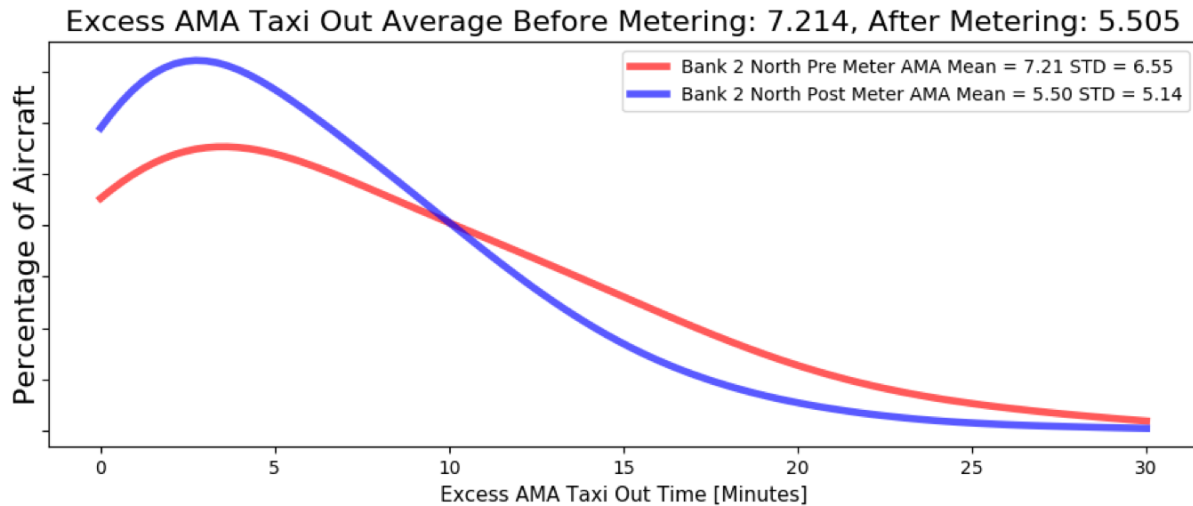


North Flow - Average Excess Taxi Out Time During Metering



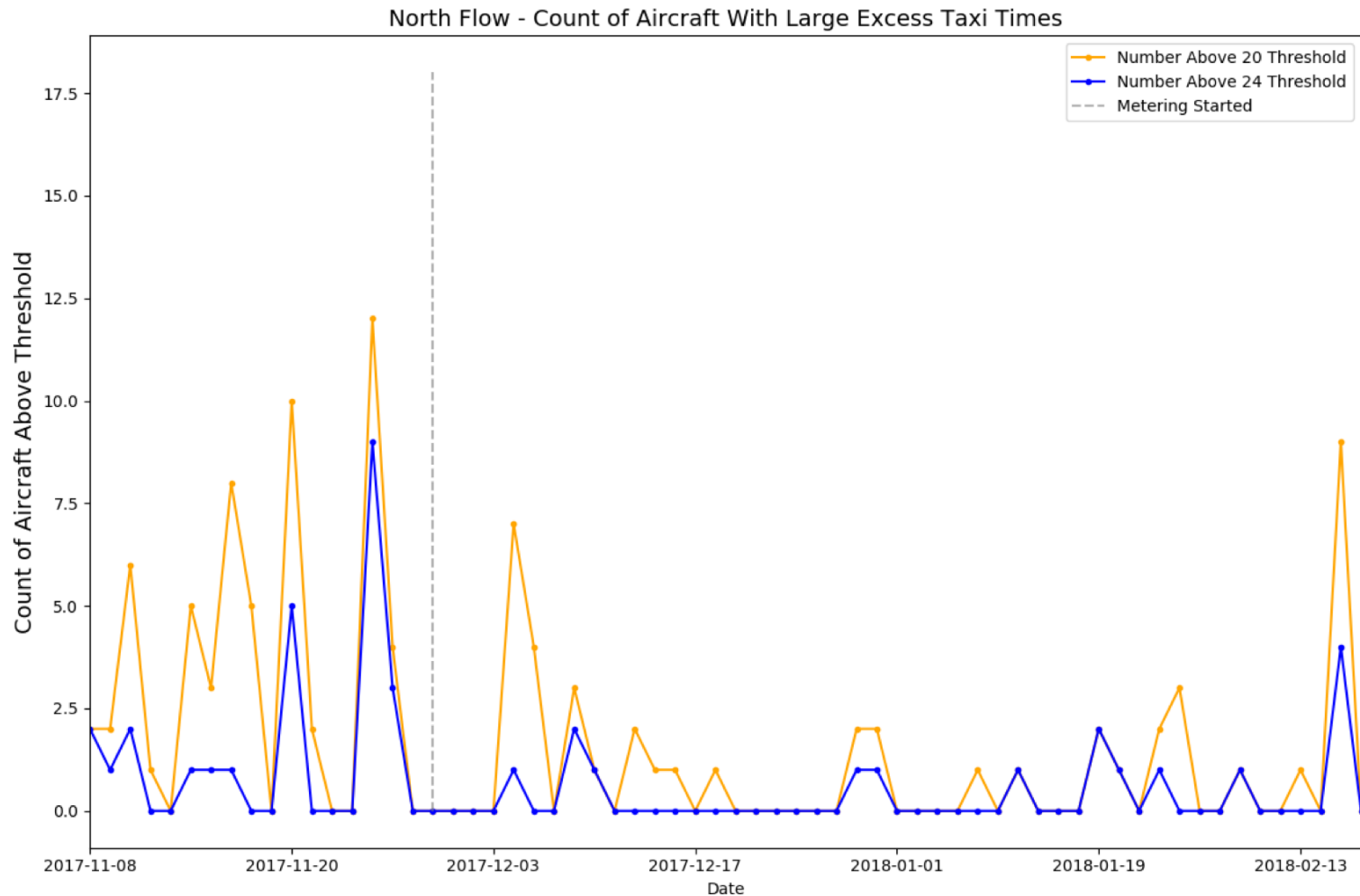
Bank 2 North Flow Average Excess Taxi Out Time





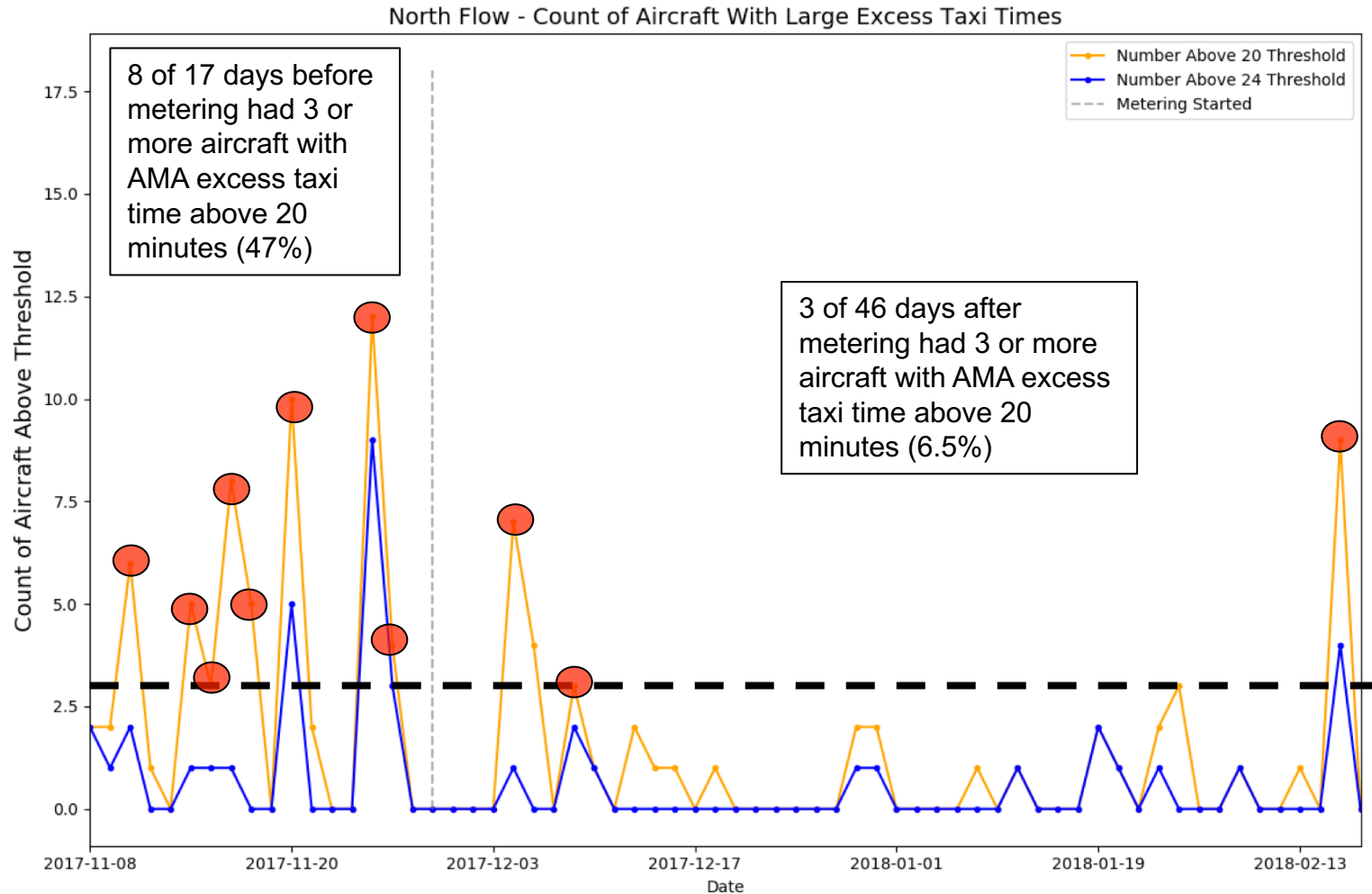
By reducing the percentage of flights with AMA excess taxi out greater than 10 minutes we reduce average taxi time

Bank 2 North Flow Count of Aircraft with Large Excess Taxi Time



Number of aircraft with AMA excess taxi time greater than 20 and 24 minutes is reduced by metering

Bank 2 North Flow Count of Aircraft with Large Excess Taxi Time

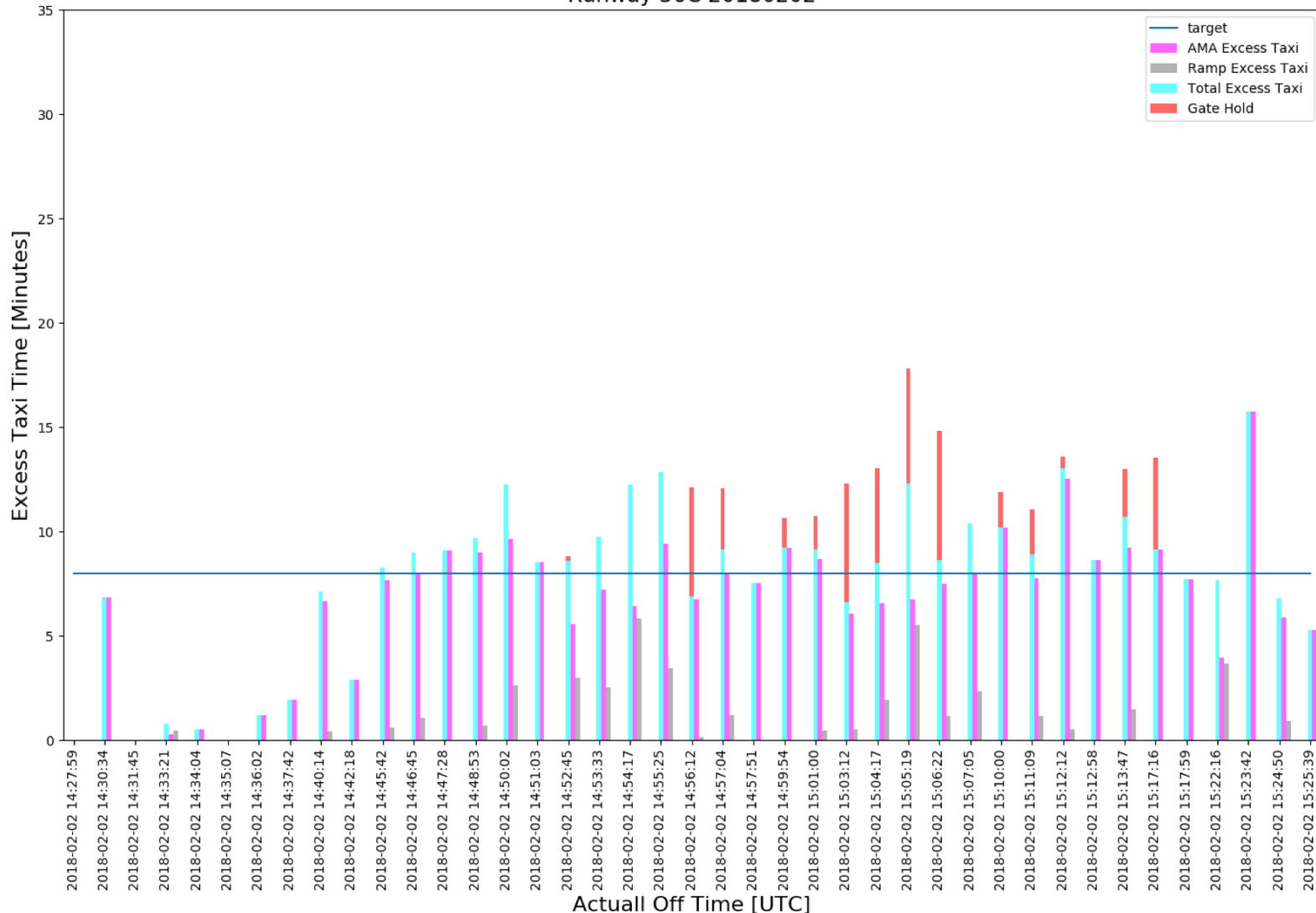


Number of aircraft with AMA excess taxi time greater than 20 and 24 minutes is reduced by metering

Flight by Flight Analysis of AMA Excess Taxi Out

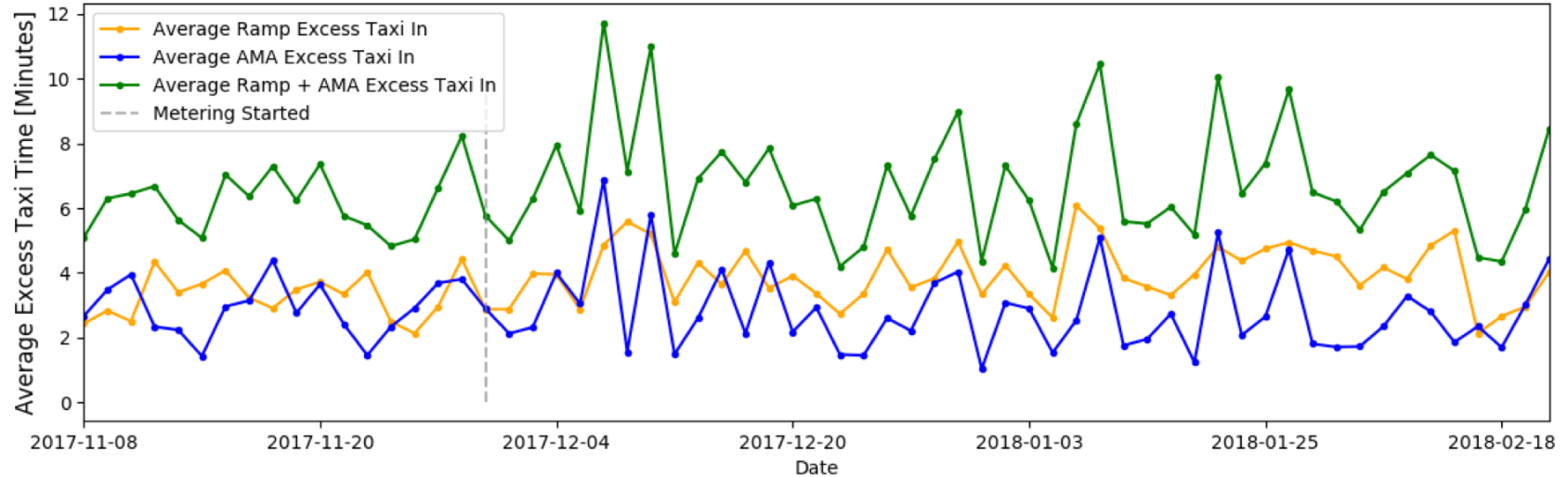


Runway 36C 20180202

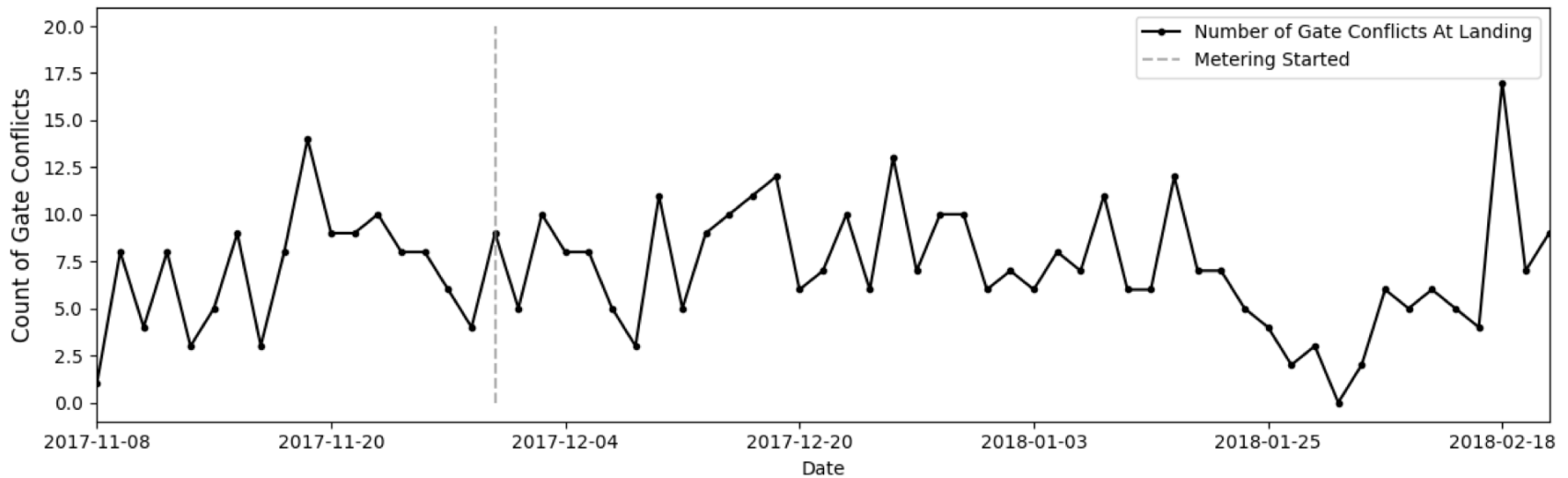


Excess taxi time above the target is transferred to the gate

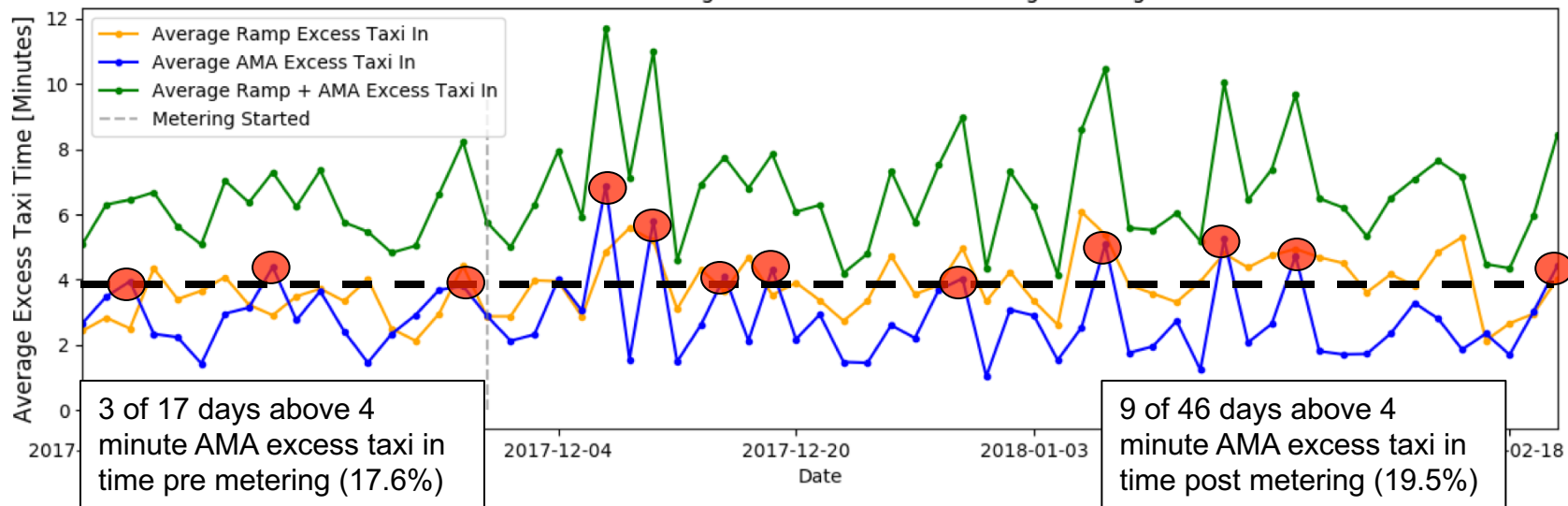
North Flow - Average Excess Taxi In Time During Metering



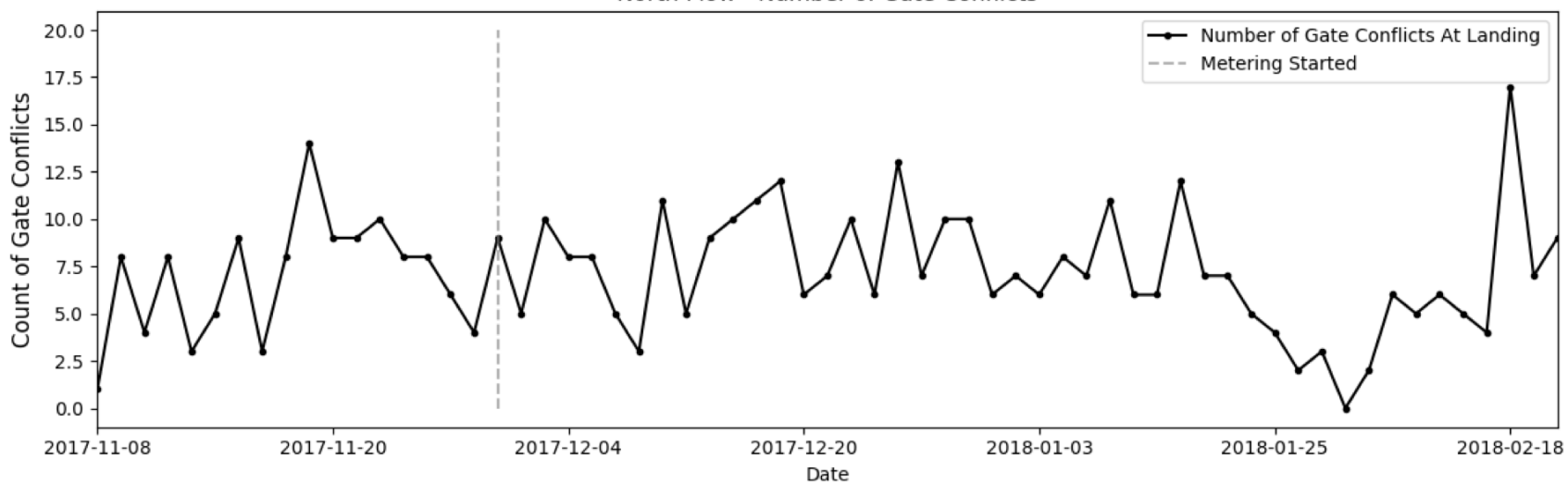
North Flow - Number of Gate Conflicts



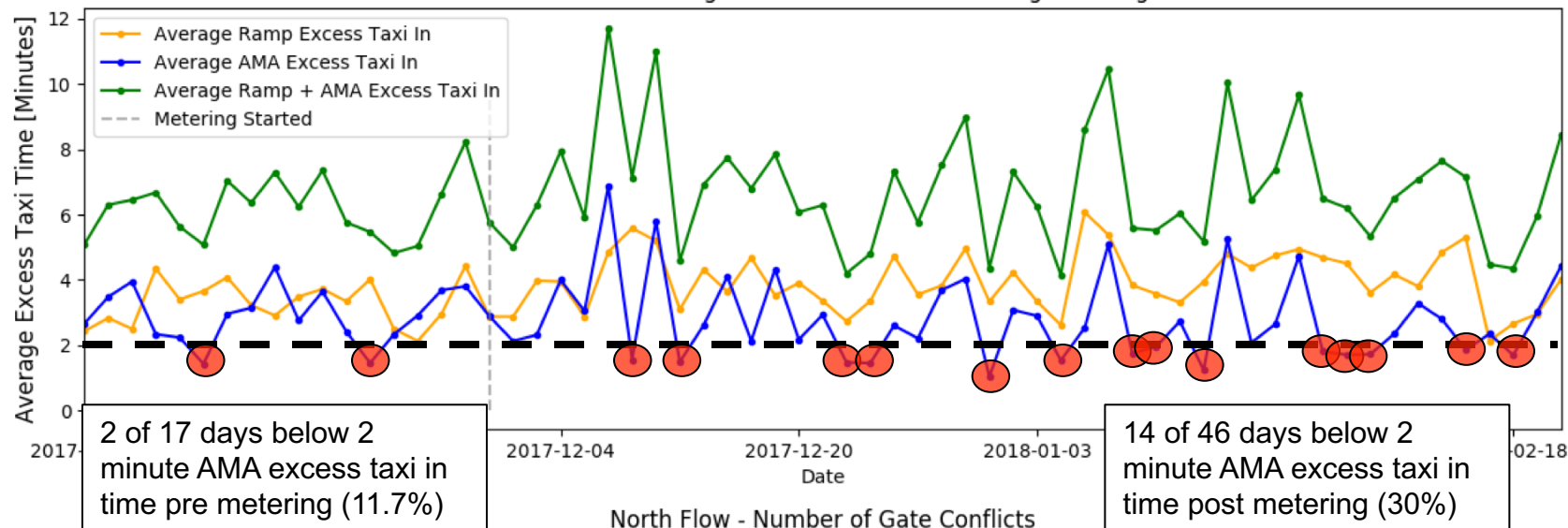
North Flow - Average Excess Taxi In Time During Metering



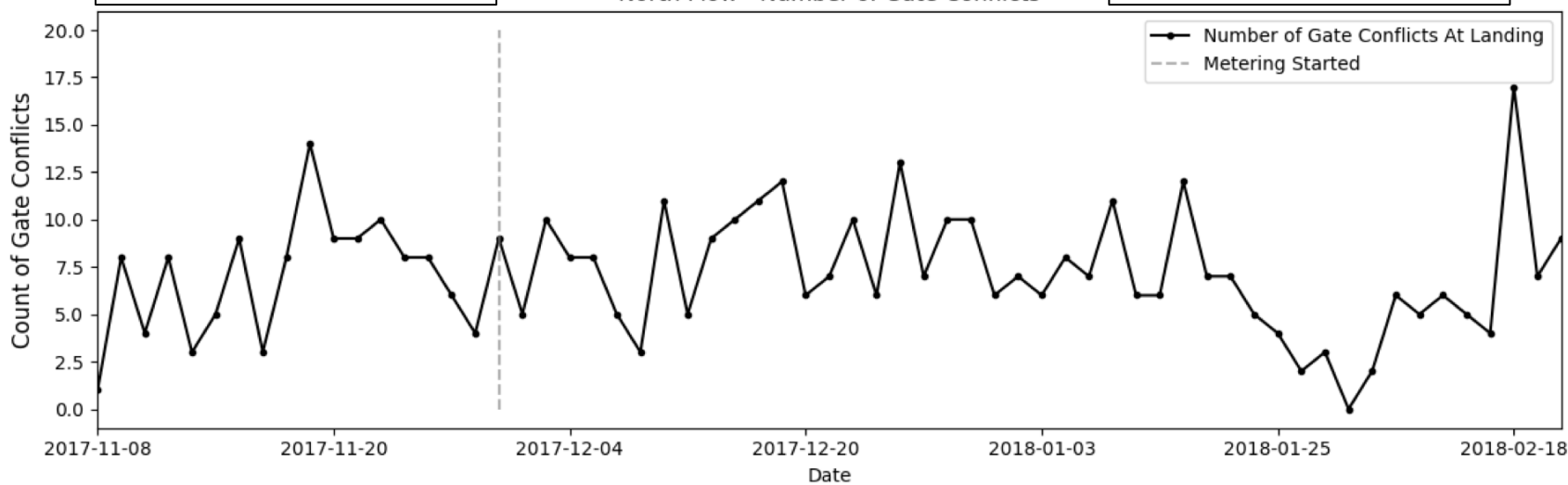
North Flow - Number of Gate Conflicts

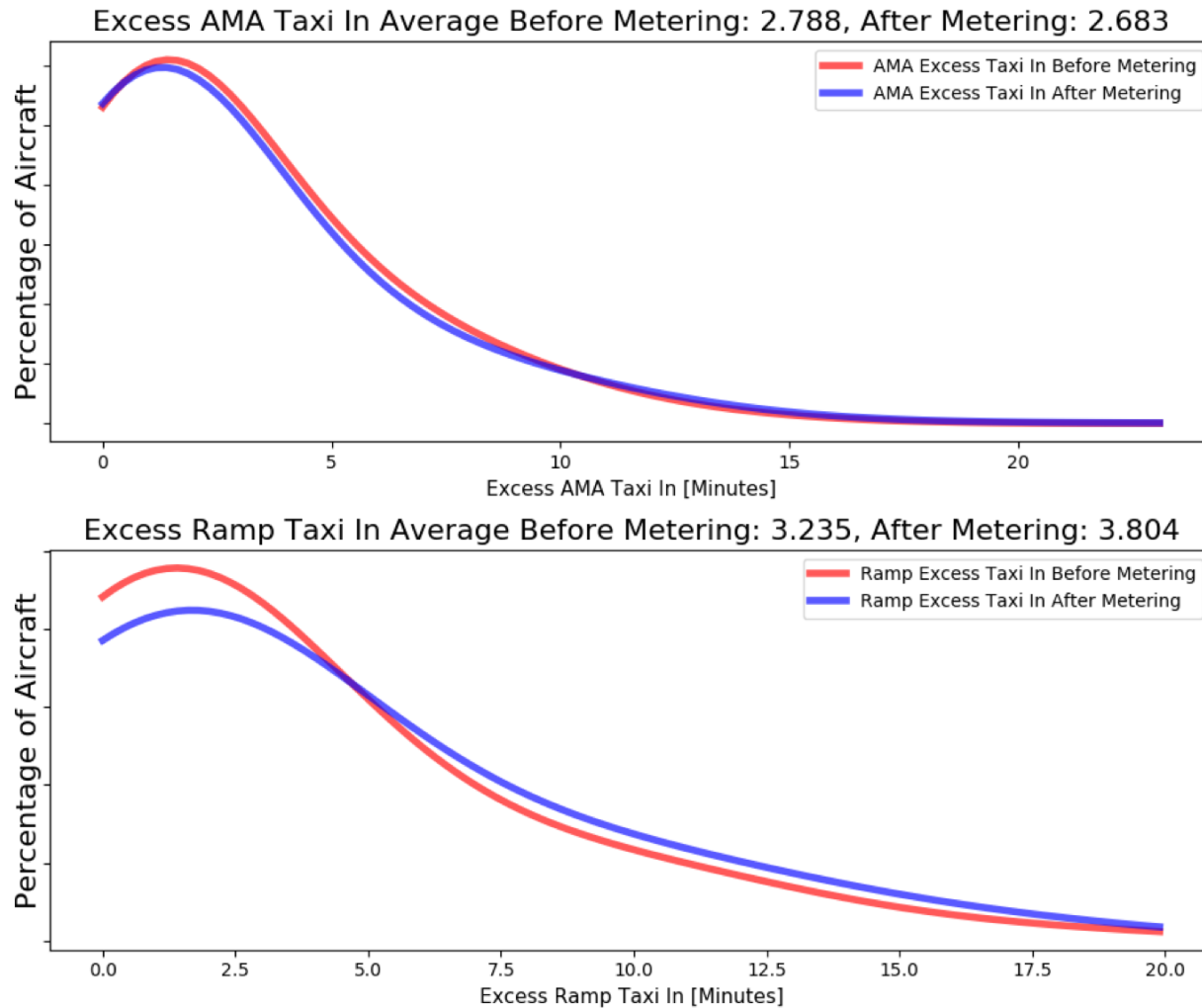


North Flow - Average Excess Taxi In Time During Metering



North Flow - Number of Gate Conflicts

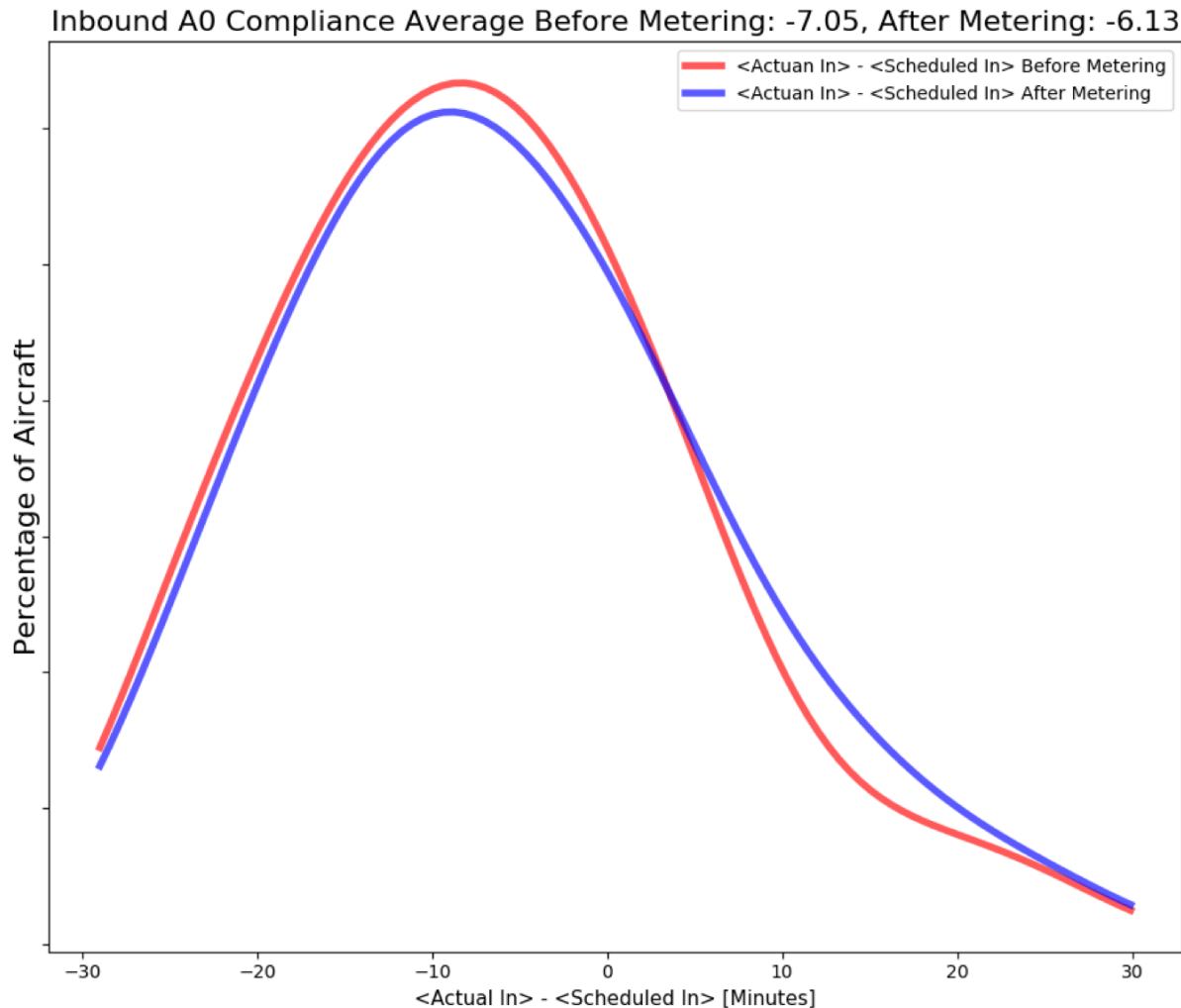




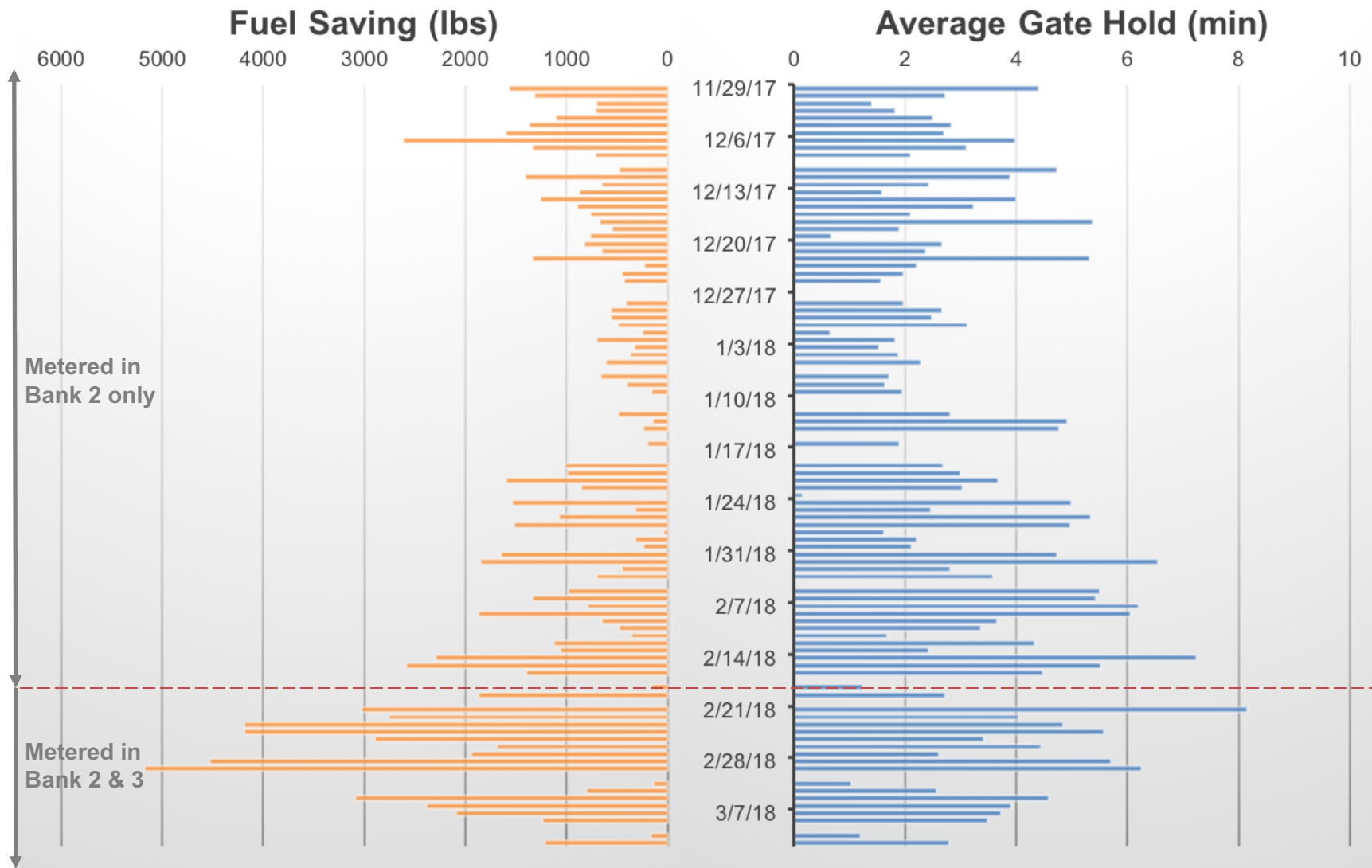
Overall impact of surface metering on
arrival excess taxi in time is modest

Bank 2 North Flow Inbound Arrival

<Actual In – Scheduled In>

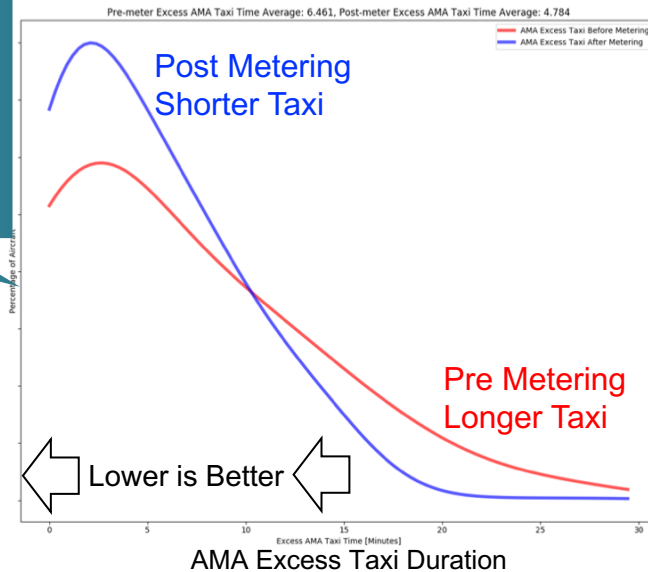


During metering the inbound arrival flights actual in are on average six minutes early compared to scheduled in (A0)

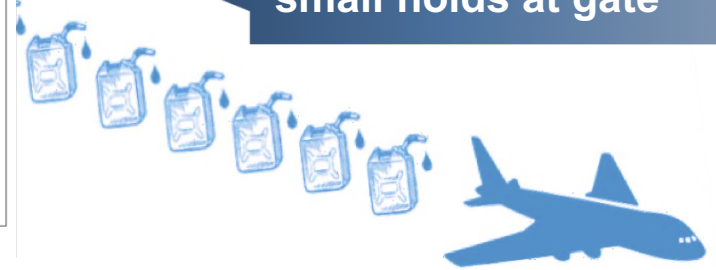


Initial benefits observed from S-CDM surface metering during Bank 2 and 3 at CLT:

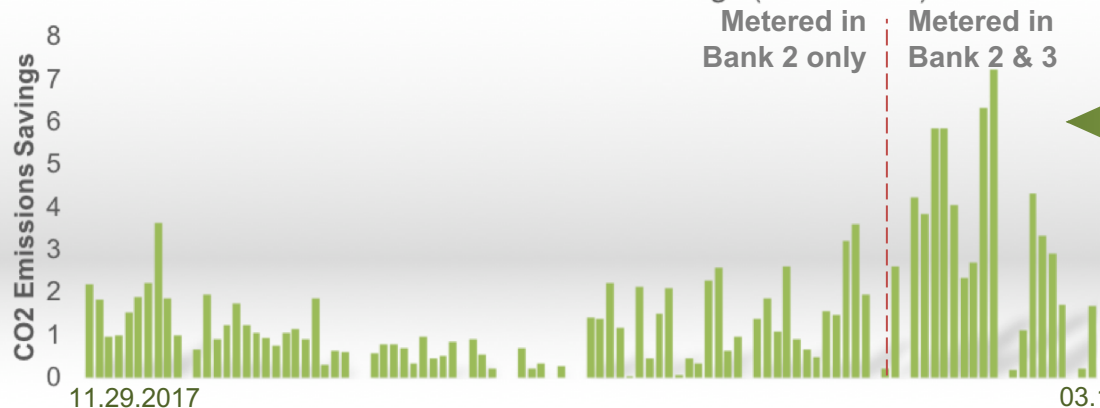
Reduced AMA taxi out times during its use via small holds at gate



Saved approximately 104,339 lbs of fuel by small holds at gate



Total Estimated CO₂ Emissions Savings (metric tons)

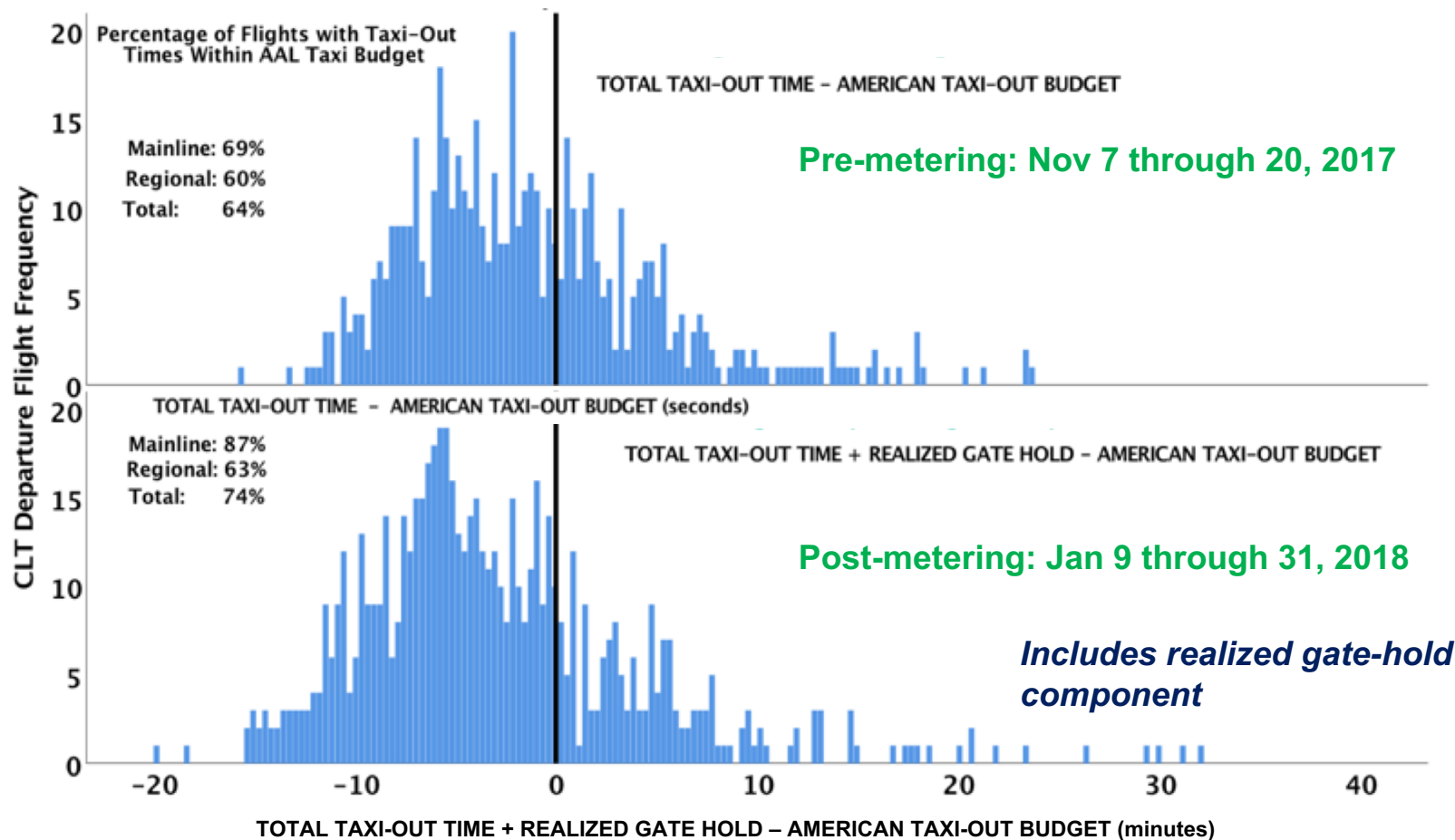


Saved approximately 146 metric tons of CO₂, equivalent to planting 3,738 urban trees

- On-time arrival (A0, A14)
 - Purpose: show whether departure metering affects on-time arrival performance at destination (outbound from CLT)
 - Defined as AIBT – SIBT
 - Currently an ATD-2 key performance parameter, with goal of *do no harm*
- Departure duration conformance to airline flight-planning budget
 - Purpose: show extent to which actual departure duration, with and without gate-holding, conform to AAL scheduled block-time budget for taxi out
 - Defined as:
 - $\text{DepartureBlockConformance} = (\text{gate hold time}) + \text{actual taxi-out time} - \text{SBT}_{\text{taxi-out}}$

DepartureBlockConformance

Pre vs Post Metering, Bank 2 AAL Departures

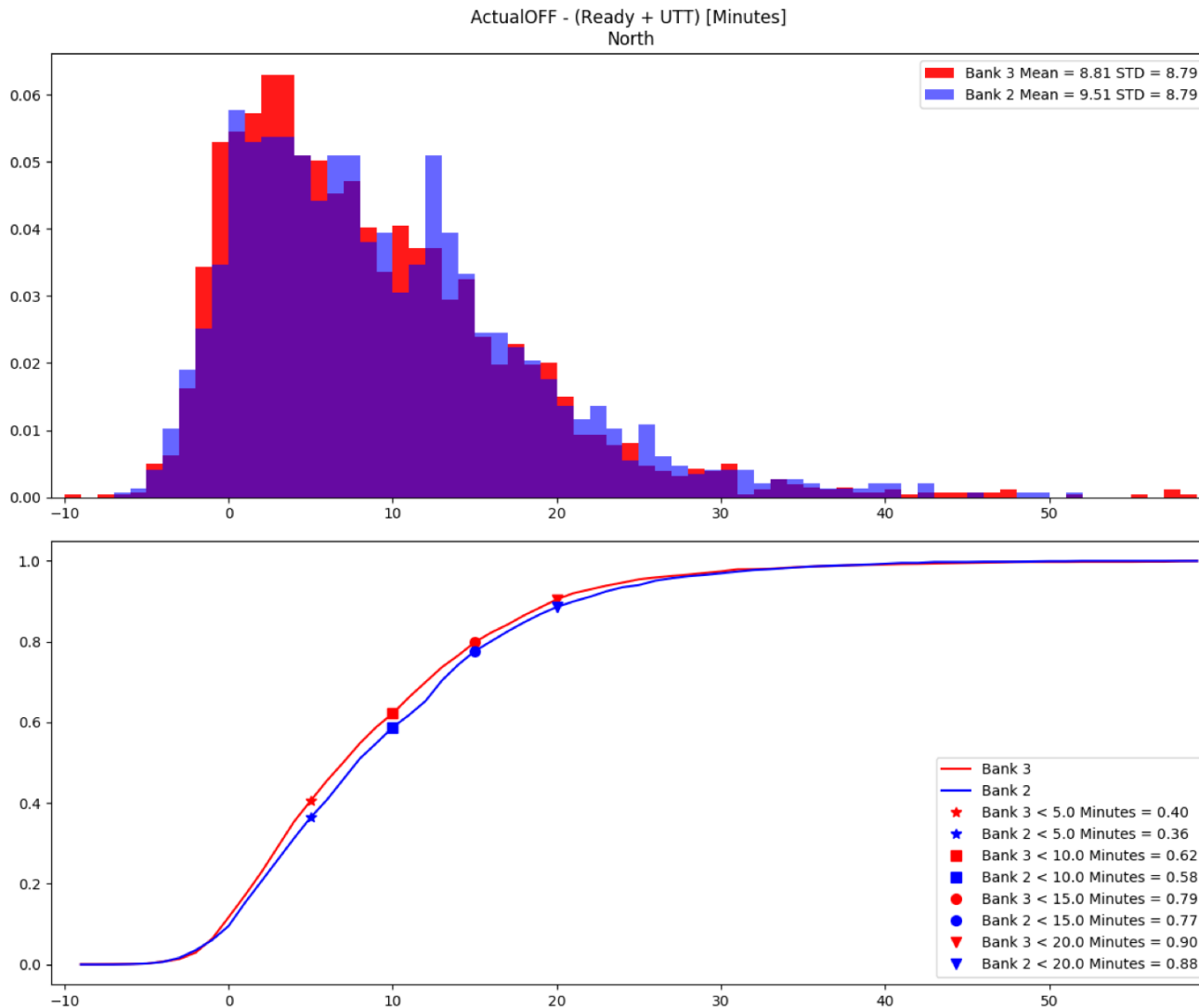


Better conformance to AAL budget seen during metering, even with realized gate-hold added to taxi-out time (based on a limited set of data)

- On-time takeoff
 - Purpose: show whether metering affected on-time takeoff performance from airline's perspective
 - Defined as $ATOT - (SOBT + SBT_{\text{taxi-out}})$
- Target takeoff time conformance to airline schedule
 - Purpose: show how TTOTs generated by IADS compare to airline-scheduled* takeoff times
 - Defined as $TTOT - (SOBT + SBT_{\text{taxi-out}})$
- TTOT at Ready versus Actual OFF plus buffer
- Cross correlate with ASPM Data and work with AAL to leverage methods currently used to assess A0/A14

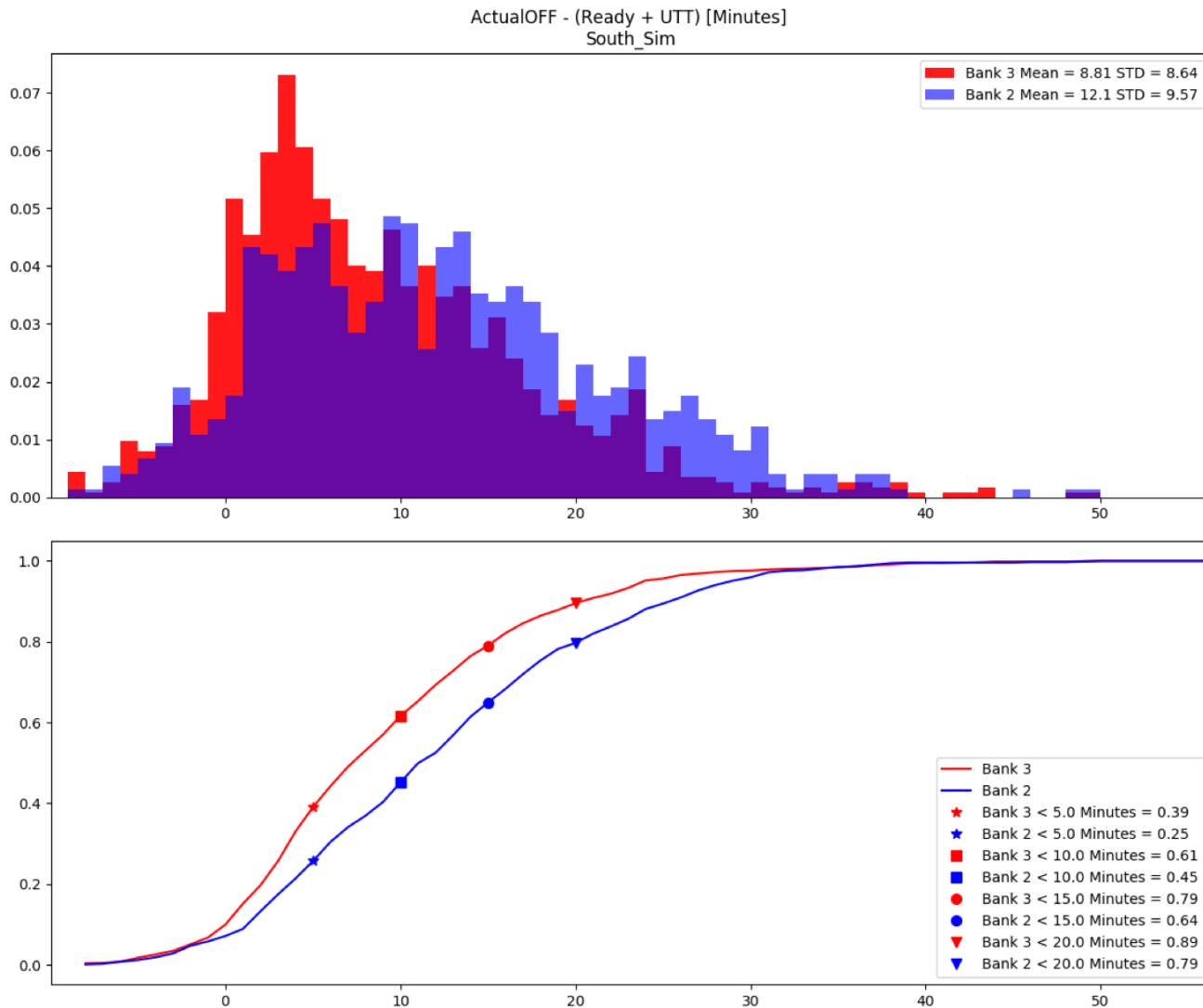
*Scheduled takeoff time is not published value, so we are deriving it based on SOBT

North Flow Bank 2 vs Bank 3



North flow: metering does not have a significant impact on the overall time aircraft spend on the surface after they call ready

South Sim Flow Bank 2 vs Bank 3



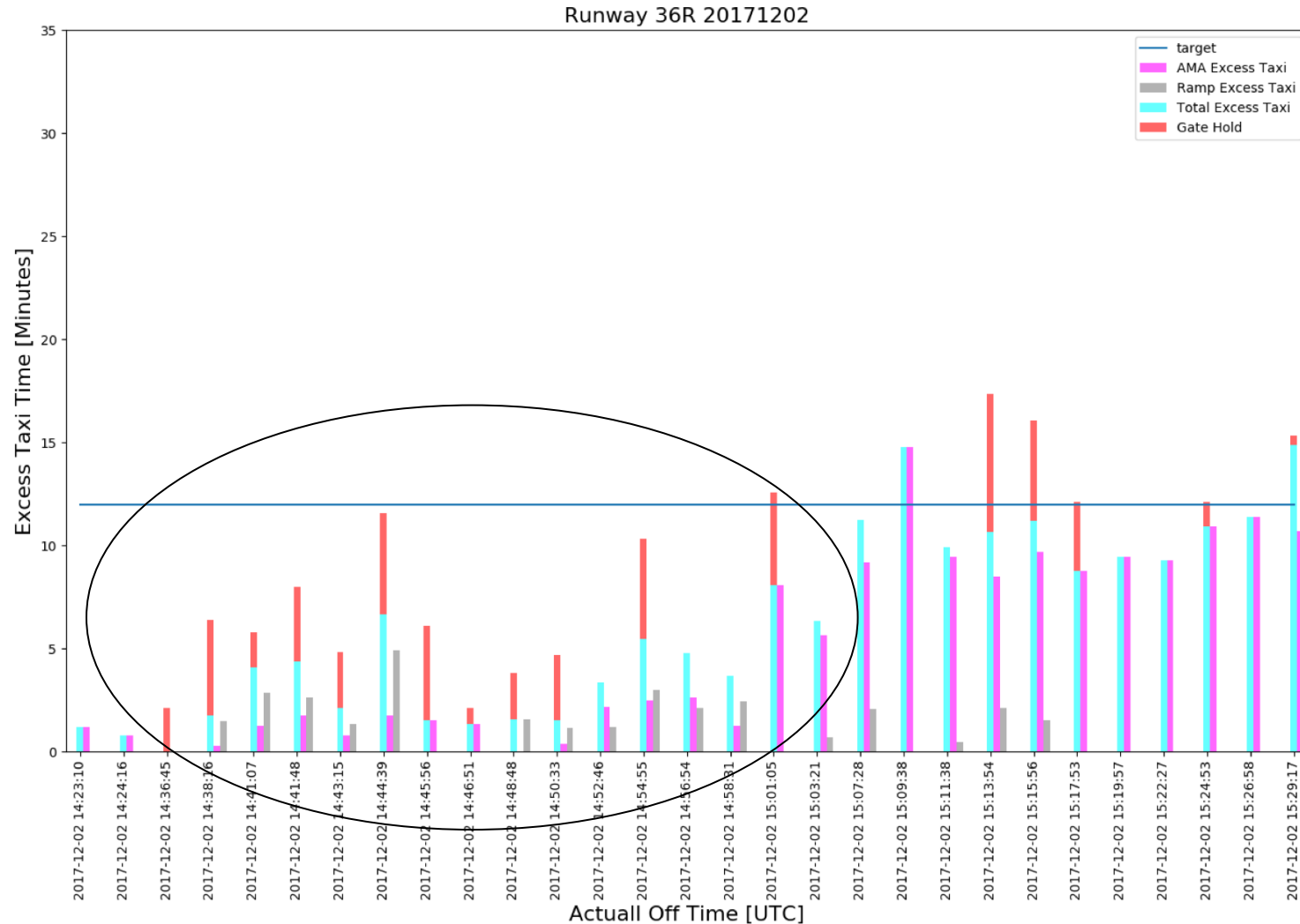
South flow: during metering of bank 2 aircraft spend more time on the surface after they call ready compared to unmetered bank 3

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- Initial Surface Metering Analysis Results
- **Lessons Learned**
- Next steps
- User Feedback / Q&A

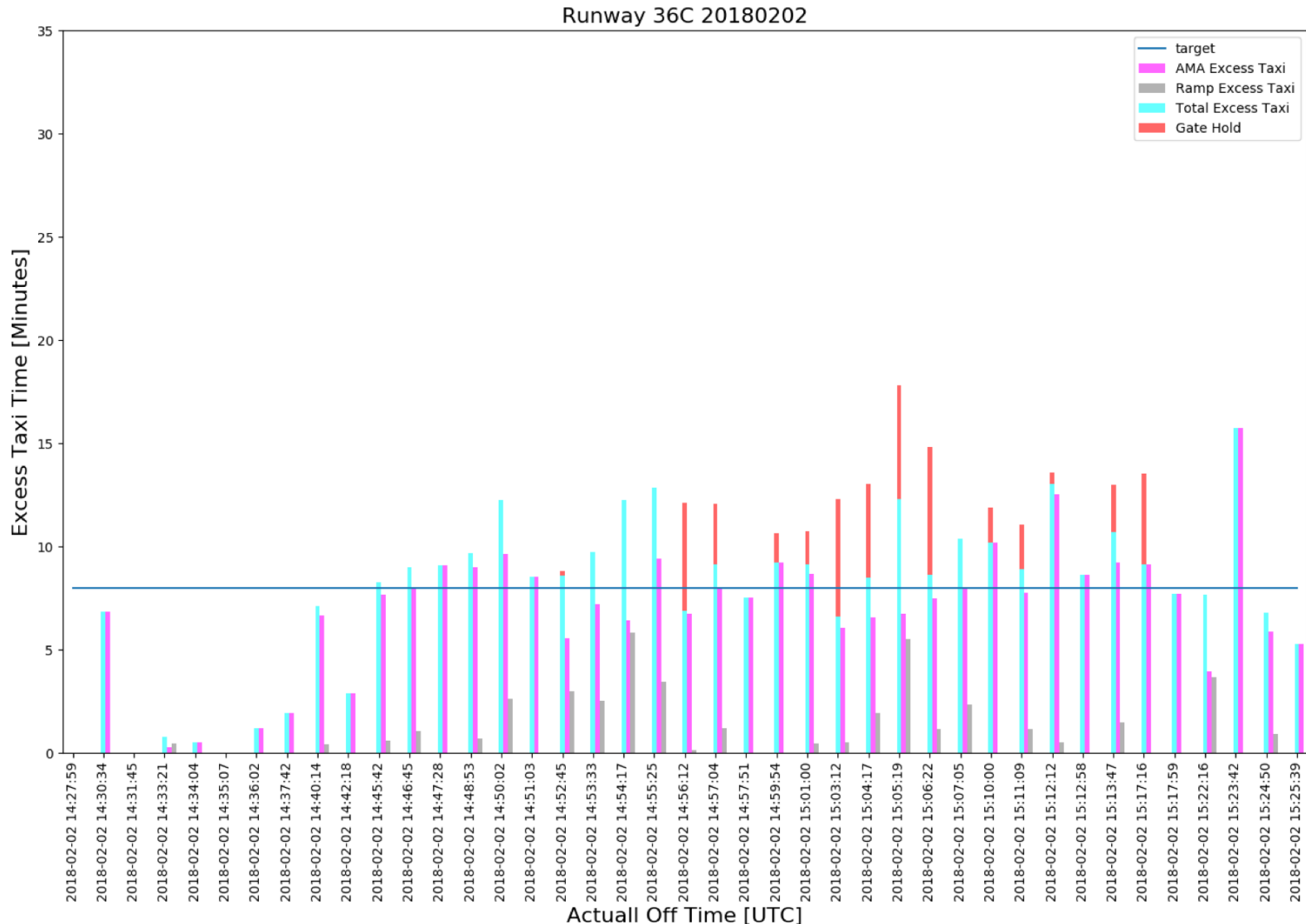


Lessons Learned from the Operational Field Evaluation

- EOBT uncertainty can lead to to inaccurate demand predictions and may result in inaccurate hold advisories
- For maximum benefit and flow performance, the ability to front load a bank is important to both departure and arrival flow performance. Otherwise, a 'slow start' may ripple through the bank
- The 'invisibility' of EOBTs, metering guidance on ramp displays and communication of guidance to pilots and ground crews require a cultural adjustment
- Runway target excess queue times need to be different for a dual use runway compared to a dedicated departure runway
- South flow operations present a bigger challenge than north flow operations
- Utilizing Priority flights appears a better way than exempting flights for handling gate conflict situations



Metering triggered early resulting in flights being held against EOBT and queue not building up properly



Metering triggered after the queue built up

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- Lessons Learned and Challenges
- **Next Steps**
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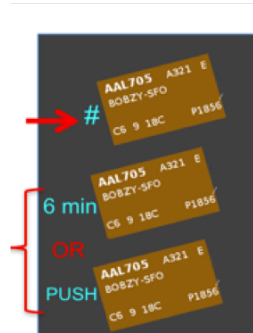
- Continue to calibrate metering parameters, especially for South configuration through analysis and user feedback for better performance
- Explore figures of merit out of important metrics to assess the overall performance of surface metering on a daily basis (or in real-time)
- Incorporate arrival runway crossings in departure scheduling
- Continue to improve accuracy of trajectory prediction through a realistic model of pushback duration and taxi speeds in the ramp and AMA
- Develop a test harness for testing scheduler in advance before deploying in the field
- Explore ability of ramp controllers to comply with TMATs and freezing TOBTs and TMATs via a HITL environment testing



Backup Slides

Nominal Gate Hold

- Planning group flights
 - EOBTs within planning horizon
 - PUSH or HOLD advisory
- Uncertain group flights
 - EOBTs outside planning horizon
 - Click # to show PUSH/HOLD advisory



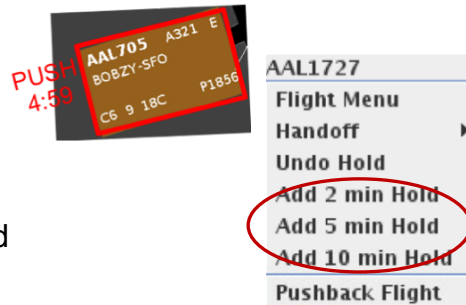
Early Pushback

- RTC shows TMAT on flight strip or aircraft icon
- For the AC sent to the hardstand RTC alerts the ramp controller to communicate with the pilot



Extend Gate Hold

- Hold advisory turns to a count up timer to indicate pushback is delayed
- Ramp controller can add extra hold time to prevent the flight from being placed into the Uncertain group



APREQ/EDCT flights

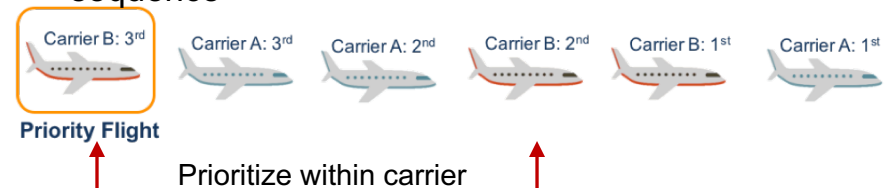
- Pilot contacts Tower at pushback ready and Tower electronically negotiates with Center for release time
- The scheduler calculates TOBT/TMAT to meet the release time
- PUSH/HOLD advisory is displayed on RTC regardless of metering on/off

Exempt flights

- User can designate exempt flights on RTC
- Not subject to surface metering hold
- International and Heavy jet flights will be exempted by default

Priority flights

- Opportunistically swap scheduler sequence without affecting other carrier scheduler sequence



Assessing surface metering is a complex topic given the variation of day to day operations and the potential impact of a wide range of variables. The analysis underway informs the continued calibration of the system as well the generation of a verified set of benefit metrics.

